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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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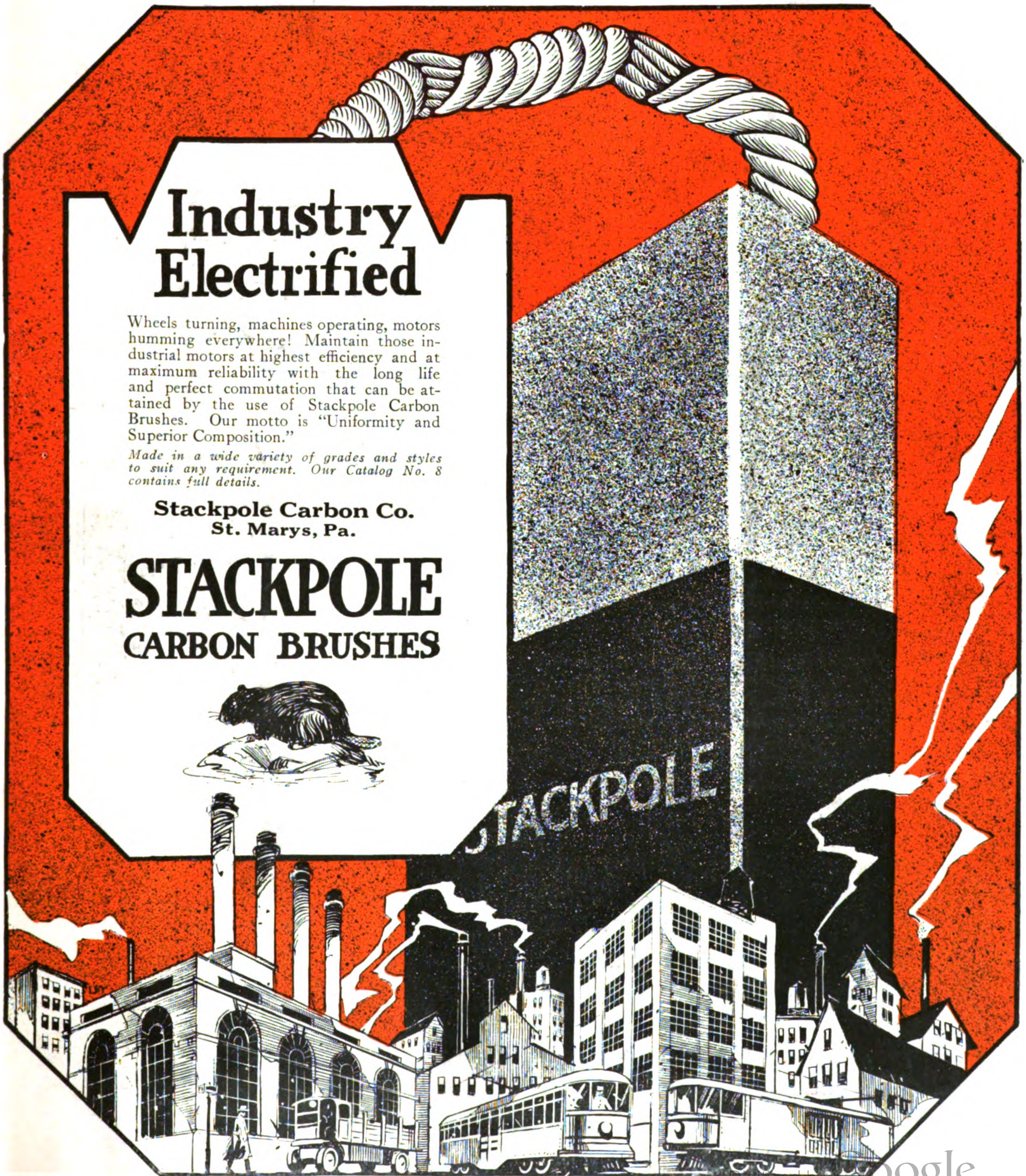

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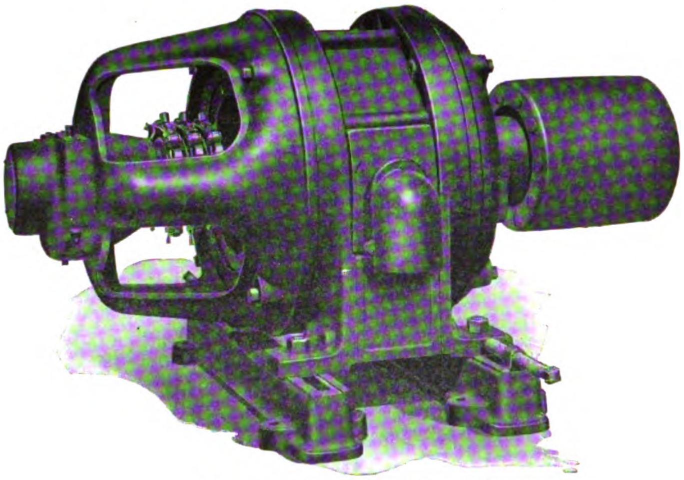

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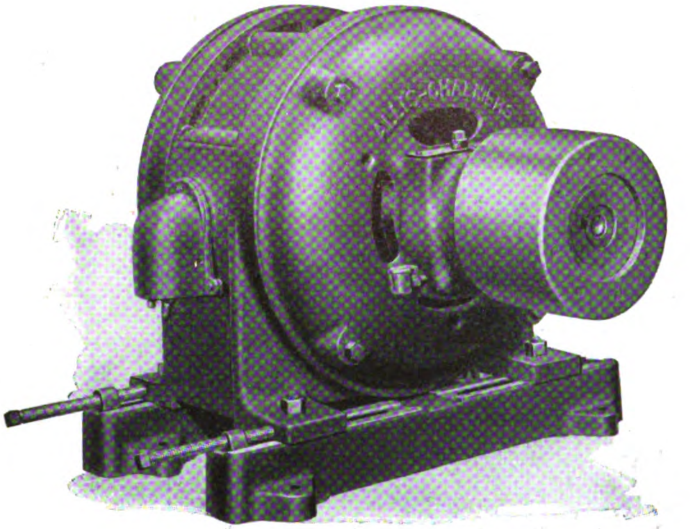

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INDUSTRIAL ENGINEER

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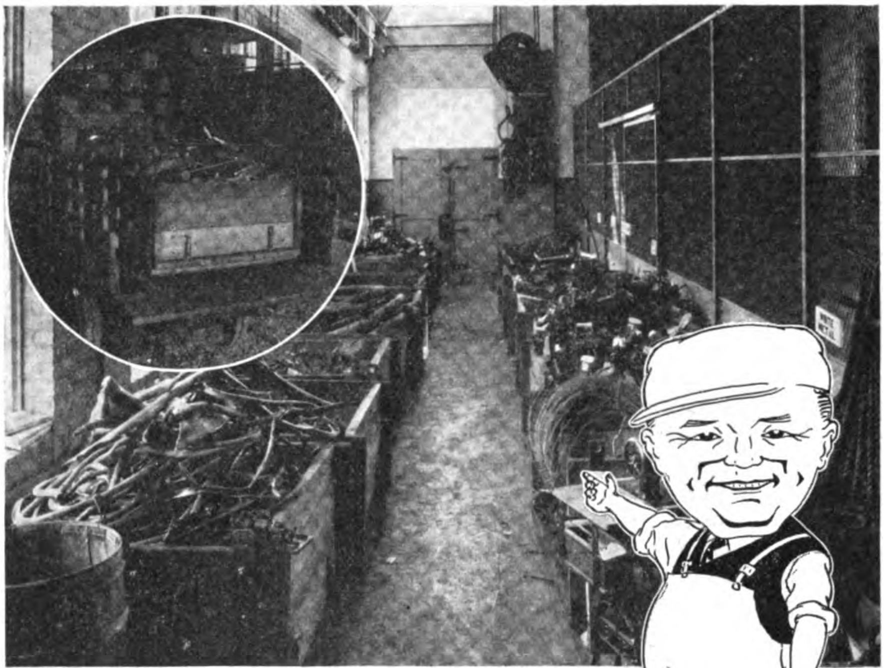
Volume 82 Chicago, January, 1924 *Number 1*

Do You Know What Is In Your Junk Pile?

If Not—Here's a Good Scheme You Can Use to Find Out and the Sorting Will Pay in the Better Rates for the Junk



THESE two photographs present a study in junk values. In most plants junk is just junk and when sold its value is based upon what appears to be the bulk of the material in the pile. In a New England plant where these pictures were taken, however, someone has found out that it's about as easy to sort junk materials while they are being accumulated as it is to dump everything together in one large pile. Besides, his idea has shown a nice profit for the maximum junk value is obtained for the different materials and the box scheme makes handling and weighing a very easy matter.

While visiting with the works engineer of another large plant a little while ago he told me that a lot of materials heretofore sold at junk values were now being refined and sold as metal of a definite composition. This expenditure in refining has shown a handsome profit.

We referred several months ago to an automobile plant where the maintenance engineer had found that his junk pile was worth about $500,000 a year through studying how junk is handled as a commercial product first from dealer to the yard, yard to the junk broker and broker to the junk user. This value was obtained by sorting junk material into the grades that are in demand.

Waste in the form of scrap ends, and miscellaneous this and that, may be unavoidable in connection with certain kinds of manufacturing but it may also represent carelessness and indifference on the part of someone. Any plan of handling junk materials and keeping track of their kind and value besides being a profitable way of disposing of it, can also be used to check up the source of this waste and the rate at which it accumulates. On the basis that hindsight is often more keen than foresight an accurate record of production wastes sold as junk can be used to avoid repetition of poor guesses that sometimes sneak into the making up of a raw material schedule in a large works.

Since this is good resolution time for a new year this plan of getting maximum value for the junk pile is a good one to add to a revision of last year's list.

Practical Pete

Activities of the

American Telephone and Telegraph Company

And Its Manufacturing Organization, the

Western Electric Company

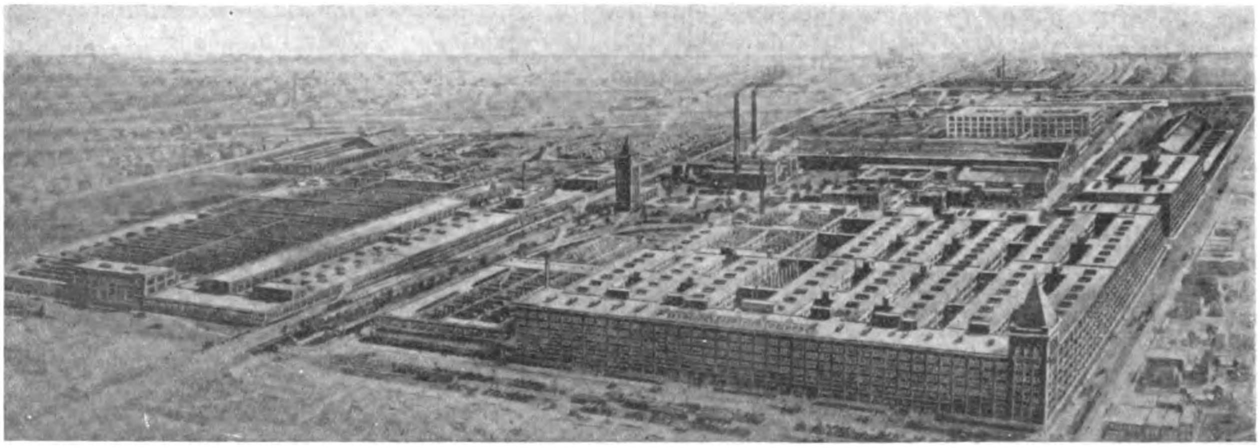
Any two of the 15,000,000 telephones in the United States can be connected for conversation. The thirteenth of a series devoted to the growth and extent of our basic American industries.

Bell's first instrument and a modern dial desk 'phone.
The telephone of Alexander Graham Bell in 1875 consisted of an electromagnet before which was suspended a strip of iron attached to a vellum diaphragm. The vibrations of the diaphragm caused corresponding changes in the current, supplied by a battery, flowing through the coil. The dialing 'phone is used in connection with automatic machine switching telephone systems which make the connection automatically.

COMPARE these pictures: 1875, two crude instruments on which words were with difficulty transmitted from one room to the next; 1923, almost 15,000,000 telephones, any one of which may be connected with any other even though the two be separated by the width of this country. This comparison will give some idea of the development of the system of the American Telephone and Telegraph Company.

This company was formed in 1885 by the American Bell Telephone Company for the purpose of building and operating long distance lines to interconnect the companies, licensed under Bell patents, that were giving local service where before 1875 business was transacted largely by messenger boys instead of the almost instantaneous telephone connection. For fourteen years it was distinctly the telephone company of long lines. Then it succeeded the American Bell Telephone Company as the central company of the federation that has become the Bell System. Besides owning and operating the physical plant that unites the associated companies into one system, it handles all national problems affecting it, protects all patents, and is the headquarters of invention, information, capital, and legal protection for the entire federation of Bell companies. Only by such a federation, whereby each local company must use standard equipment and standard methods, could satisfactory, long-distance communication be possible. Realizing this, the parent company early undertook the search for improvements in the telephone art, and the supervision of the development of scientific discovery and

The Hawthorne (Chicago, Ill.) plant of the Western Electric Company.
Practically all the telephones, switchboards, cables and other equipment used by the American Telephone and Telegraph Company in all their systems in the United States, are made by the Western Electric Company. This Chicago plant covers 200 acres, consists of 102 buildings containing 4½ million feet of floor space and employs 38,000 workers. It is estimated that it requires a week for a man to casually walk through the various aisles and departments and give even a superficial glance at all the operations performed. The group of buildings at the left of the railroad track, through the center of the plant, is devoted to the manufacture of cable and enameled wire. The largest telephone cables manufactured contain 1,200 pairs of wires, insulated and enclosed in a heavy lead sheath. One-eighth of the lead produced in the world is used for this purpose. About 85,000 tons of copper, lead and insulating paper are used annually for making lead-covered telephone cable alone.



Only one-fifth of the 1,900 telephone buildings owned by the Bell System.

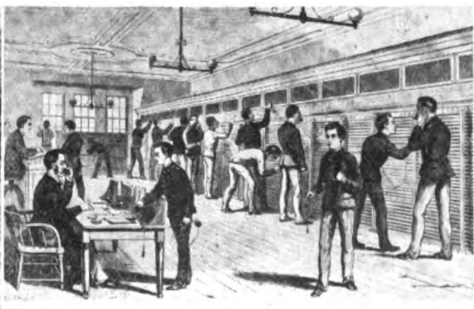
Almost two-thirds of all the telephones in the world are in this system. The operation of this requires over 250,000 employees. The 6,000 exchanges handle about 42,000,000 telephone calls every day. Of the 15,000,000 telephones in the United States, any one may be connected with any other even though they may be separated by the continent.

the manufacture of telephone apparatus and equipment.

The result today of all this coordinated activity is an American telephone system that interconnects nearly two-thirds of all the telephones in the world, has over 250,000 employees, has 6,000 exchanges that handle 42,000,000 telephone conversations every day, and owns physical assets costing over $1,900,000,000. All this has grown from the two-man concern of Alexander Graham Bell and Thomas A. Watson in 1876.

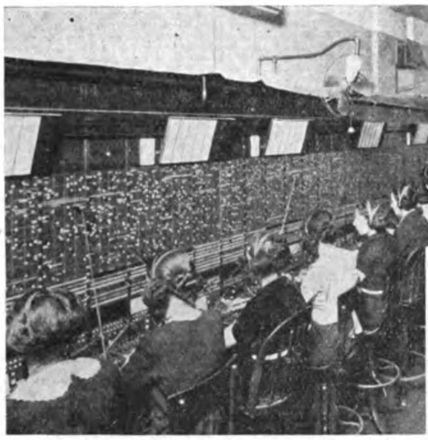
The growth of the Bell System called for coincident growth of manufacturing facilities. Until 1878 all Bell telephone apparatus was made by Watson in Charles Williams' little shop in Boston, a building long since transformed into a theatre. But the business soon grew too big for the shop. Four manufacturers of electrical apparatus, one of which was the Western Electric Company, were then given licenses to make telephone instruments and apparatus. Due to lack of uniformity the factories were combined and their product standardized.

In 1881, the manufacturing companies were merged under the name of the Western Electric Company which became, as it is today, the manufacturing unit

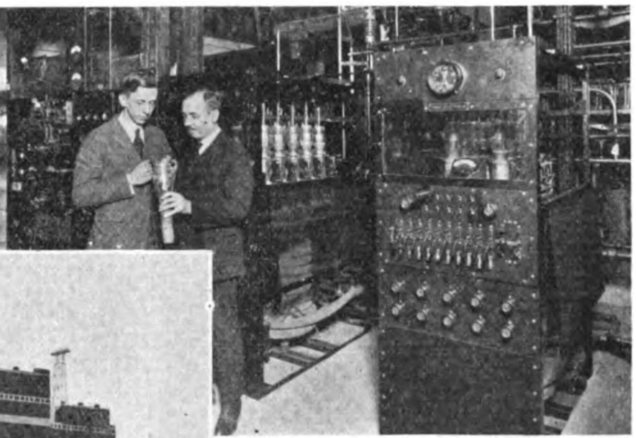


Early developments of the industry.

The two outside photographs show the corner of Broadway and John streets, New York City, in 1880 and in 1916 respectively. The American Telephone and Telegraph Company building, 195 Broadway, at the left, contains the general offices. The first switchboard in 1880 at the Cortlandt Exchange, New York City, was operated by boys.



A modern telephone switchboard. Telephone messages are usually handled by two operators; the first receives the signal of the subscriber on what is known as the "A" board and signals to another operator on a "B" board who "plugs in" and rings the party called. In machine switching exchanges the connections and disconnections are made without the assistance of central operators.

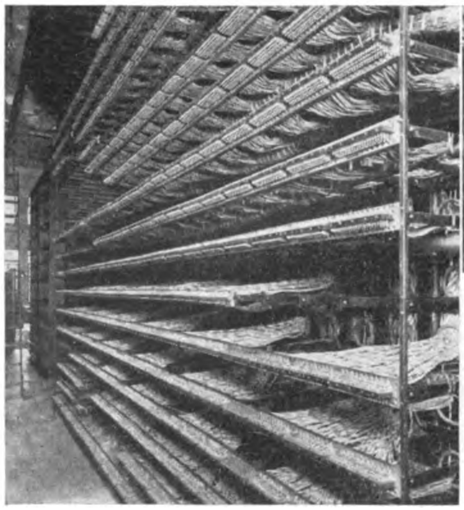


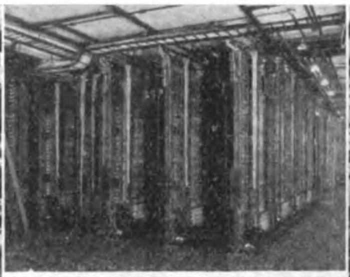
Radio broadcasting station, WEAF. The antennas of WEAF, the experimental broadcasting station of the American Telephone and Telegraph Company, is located on the Walker Street Building (at the left) in New York City, in which all the long distance telephone lines entering New York terminate. The view above shows the vacuum tube installation used in sending the voice across the Atlantic on January 14, 1923.

of the Bell System. This company is the largest of its kind in the world. At its great plant, consisting of 102 buildings covering 200 acres and containing over 84 acres of floor space at Hawthorne, Chicago, Ill., over 38,000 workers are engaged in transforming raw materials, brought from all parts of the world, into telephone apparatus in hundreds of different forms. Each year over 4,000,000 miles of wire are built into cables, enough to make 15,000 wires between New York and San Francisco. About 3,500 telephone sets are turned out daily in contrast to about 25 per day a score of years ago.

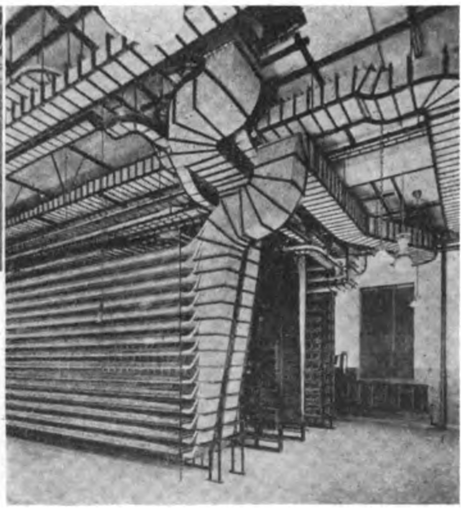
No other single company uses as much copper wire, hard rubber, or hard brass. A thousand pounds of platinum a year are used in the manufacture of contact points for telephone desk sets alone. Silk thread from Japan, paper tape from Manila, mahogany from South America, rubber from Brazil and the Congo, cotton from Egypt, linen from Mexico and Ireland, iron from Norway and Sweden, platinum from Russia and Colombia, shellac from India, tin from the Dutch East Indies, shows the diversity of raw materials used.

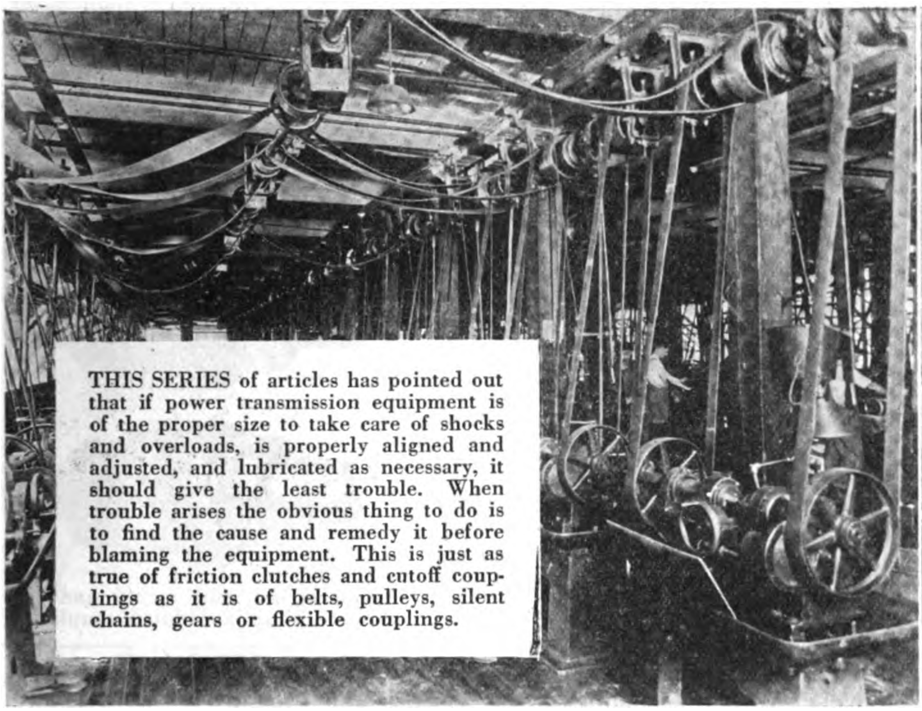
Another function of the American Telephone and Telegraph Company, which has made possible the wonderful telephone art of today, is that of development and research. The large engineering and scientific staff engaged in this work examines and studies all new patents relating to the telephone and telegraph issued in various countries, and considers all the latest discoveries in pure and applied science including problems of wire and radio transmission.

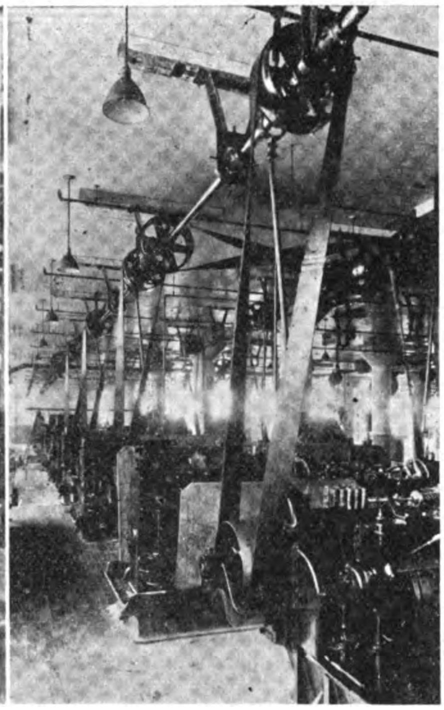




Three views in a telephone exchange. One of the switchrooms in the machine - switching CENtral Exchange in Chicago (above). The other views show small parts of "distributing frames" of two telephone exchanges, each containing miles of wire and thousands of soldered joints.







By driving this battery of machines from friction clutch pulleys on lineshafts, as above, it is not necessary to install the mass of belts and countershafts shown in the illustration at the left. Also, any machine or group of machines may be thrown out of action by clutches without having to throw off the belts.

THIS SERIES of articles has pointed out that if power transmission equipment is of the proper size to take care of shocks and overloads, is properly aligned and adjusted, and lubricated as necessary, it should give the least trouble. When trouble arises the obvious thing to do is to find the cause and remedy it before blaming the equipment. This is just as true of friction clutches and cutoff couplings as it is of belts, pulleys, silent chains, gears or flexible couplings.

Construction Details and Conditions Permitting

Use of Clutches and Cutoff Couplings

In Order to Reduce the Power Used by Idle Machines and by Shafting

By **FRANK E. GOODING**

Associate Editor, Industrial Engineer

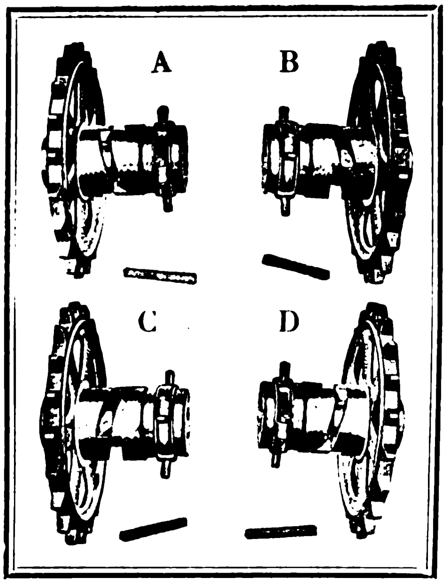
COUPLINGS, either of rigid, compression or flexible types, as have been described in articles in the October, November and December, 1923, issues of INDUSTRIAL ENGINEER, are used where the connection between sections of shafting or machines is permanent. These, however, usually may be disconnected when necessary by removing connecting bolts or pins or by dis-assembling. This is satisfactory for making repairs but is not often adaptable to operating conditions as it interferes with production.

On lineshafts, when it is desired to cut off a section temporarily at infrequent periods or for some time, spacing rings are sometimes used between the halves of flange couplings. By removing the connecting bolts, the spacing ring drops out and leaves sufficient clearance for one flange to rotate without interference with or rubbing on the other. The disadvantage of this method of connecting sections of shafting is that the driving shaft must be stopped for a few minutes either to connect or disconnect. For this reason, a section is seldom disconnected unless it is to remain idle for some time.

With friction or magnetic clutches so easily operated, there is no excuse for allowing a machine or group of machines to operate if they are to be idle for even a short period of time. This is not always taken advantage of when the disconnection is more difficult to make. Both types of clutches are also used advantageously particularly in connection with some types of synchronous motors, since these motors do not start well under load. By the use of a clutch the motor may be started light and the load applied gradually. This gives the same effect as a rheostat starting switch with a direct-current motor. Clutches are an important safety element in many machines in that in case of accident either to the operator or to the machine, tripping of the clutch will instantly disconnect and stop the machine instead of having to wait to stop the driving motor or engine or shift a belt.

Friction cutoff couplings, clutches and quills enable a section of shafting on a machine to be connected or disconnected almost instantaneously at will by a lever.

A friction cutoff coupling is ordinarily used to connect and cut off two sections of shafting. One-half of the coupling is usually keyed solidly to one shaft while the other half is keyed either solid or by a feather key to the other shaft. By different mechanical devices such as a lever, toggles, springs, spiral gears and other devices, one-half of the coupling is made to seize and clamp the other half. The friction clamping devices of clutches and cutoff couplings are quite similar in several types, particularly when a concern manufactures both cutoff couplings and clutches. In several such types



How to tell whether a spiral coupling is right-hand or left-hand.

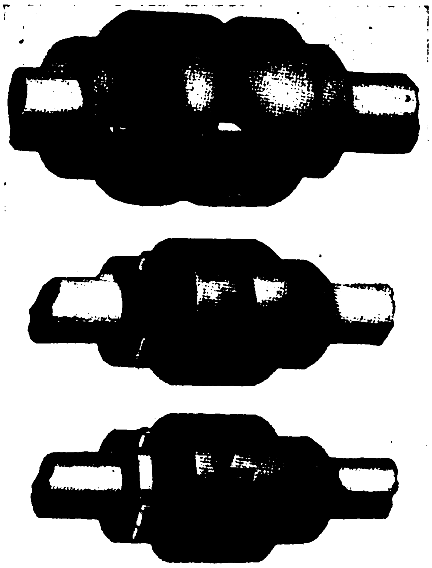
A is a right-hand spiral coupling when the wheel drives and the direction of the motion is down, or when the shaft drives and the direction of motion is up. *B* is right-hand when the shaft drives and the direction of the motion is down, or when the wheel drives and the direction of motion is up. *C* is left-hand when the wheel drives and the direction of motion is up, or when the shaft drives and the direction of motion is down. *D* is left-hand when the shaft drives and the direction of motion is up or when the wheel drives and the direction of motion is down. A simple rule is: A clutch is right-hand if you can encircle the driving part of the clutch with the fingers of the right-hand pointing in the direction of rotation and have the thumb point toward the jaws of the clutch and act as a jaw. Conversely, a clutch is left-hand if you encircle the driving part of the clutch with fingers of the left hand pointing in the direction of rotation and have the thumb point toward the jaws of the clutch and act as a jaw. The application of this rule will be easily seen after trying it out on some of the clutches pictured here. A spiral clutch will drive in only one direction.

half the clutch is keyed on the shaft and the other half fastened to a loose pulley or gear which may ride on the shaft or ride on a special sleeve or extended hub. Clamping action is usually made by a lever. In reality, cutoff couplings and clutches differ but little in principles of construction other than is made necessary by the different uses.

Two of the first type of clutch or cut-off couplings designed were what are known as square-jaw and spiral-jaw crab clutches or coup'ings, as shown above at the right. These are also called claw or tooth clutch couplings and are usually engaged and disengaged by a lever. As either type must take the full load shock when engaged, they are adapted only to slow-speed operation where there is no objection to starting suddenly and the driving mechanism or shaft does not offer heavy load or much inertia. Square-jaw clutch couplings can drive in either direction and so can be used under reversing load. Spiral-jaw clutch couplings can be used only for driving in one direction and are designated either right- or left-hand as explained in connection with the four small illustrations at the left. One-half of this coupling is sometimes cast as the hub of a sprocket, gear or pulley, if such is used. Although these are seldom recommended for operation at a speed higher than 50 r.p.m., they have the advantage that they are always self-centering when in operation.

Modern industry demands a much higher speed than 50 r.p.m. If these older types of couplings were still used, the action would be somewhat like trying to start a train by getting the engine up to full speed and letting it bump the train to get it into motion. Since the result would probably be almost as disastrous in industry, other types of couplings have been found necessary.

With the increased speed of modern industry, these types of jaw clutches could not stand the severe service at the moment of starting up and so it practically became necessary to devise a type of clutch and cutoff coupling which could. In a friction clutch, or coupling, as its name implies, the friction of surfaces connected to the driving shaft with corresponding surfaces connected to the driven parts, cause the transmission of the rotating motion. When these friction surfaces are thrown into engagement one with the other, a certain amount of slipping occurs between the two sets of friction surfaces until the speed of the driven part is brought up to the speed of the driving part. After that, if the clutch is in proper adjustment no more slipping takes place because the friction is adequate to continue the drive. In addition to friction clutches, types of magnetic clutches are also used. One of these will be described later in the article.

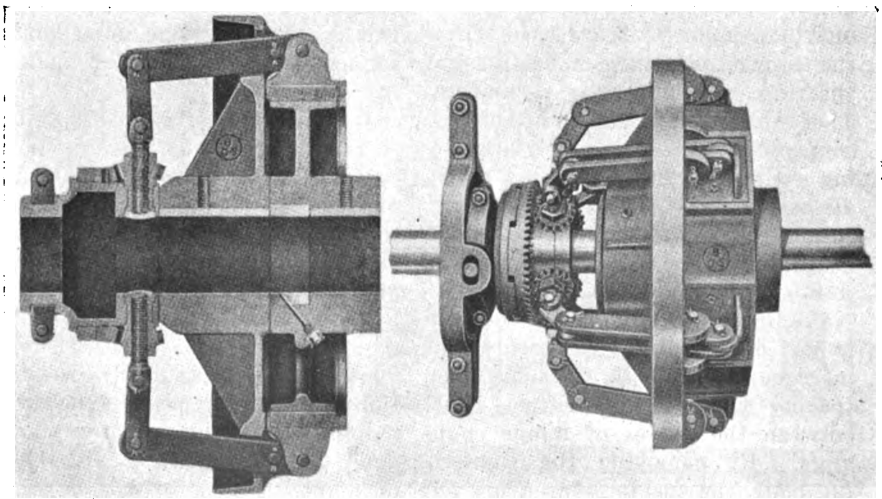


Square jaw and right- and left-hand spiral jaw clutch couplings.

Some Types of Friction Clutches and Cutoff Couplings

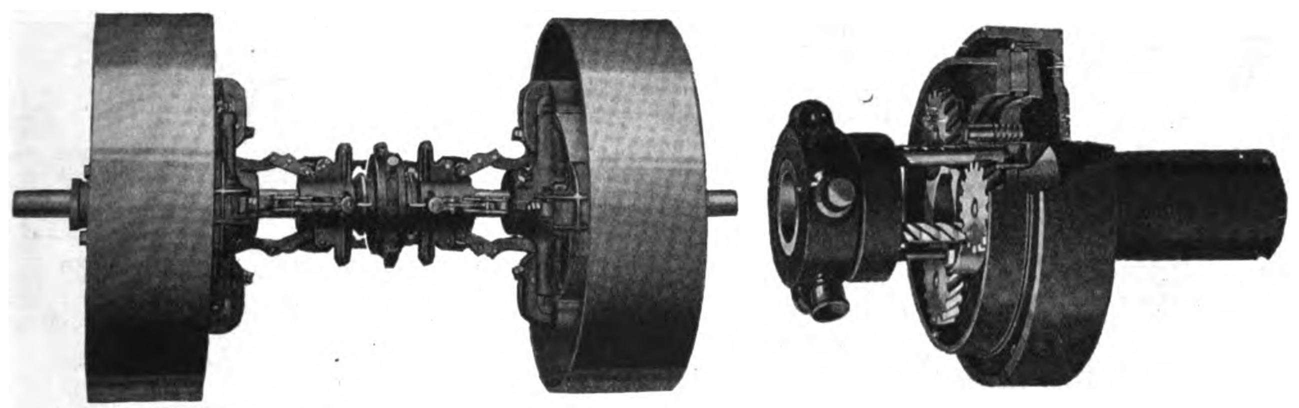
Friction clutches and cutoff couplings may be divided into three general classifications—cone, disk, and ring—according to the shape of the friction parts or clamping devices.

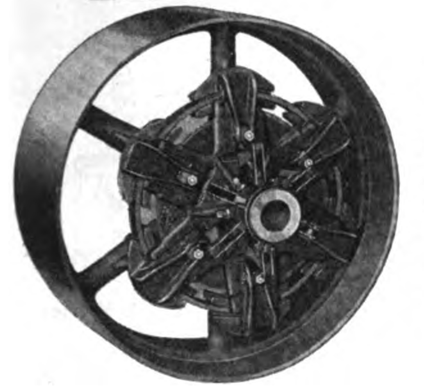
In conical friction clutches or couplings, one-half of the clutch, which consists of a frustrum of a cone, fits into the other half, which consists of a corresponding cone-shaped ring. In cutoff couplings the



One type of cutoff coupling and clutch.

Here wooden friction blocks are applied to a ring friction surface. One of the big advantages claimed for this friction clutch is the ease with which it may be adjusted evenly, to compensate for wear, by the bevel gear which adjusts all arms together.





Two applications of a ring-type friction clutch and a special type of disk clutch.

The double-throw countershaft, above, and the pulley clutch at the left, are six-arm ring friction clutches which clamp the cast-iron rings with special friction clamps on each side of the ring. The clutch above at the right is engaged and disengaged through a spiral gear which it is claimed allows the clutch to be operated at high speed with a positive gripping action. This clutch is totally enclosed and contains its lubricant. The pulley or gear is carried on the sleeve at the right.

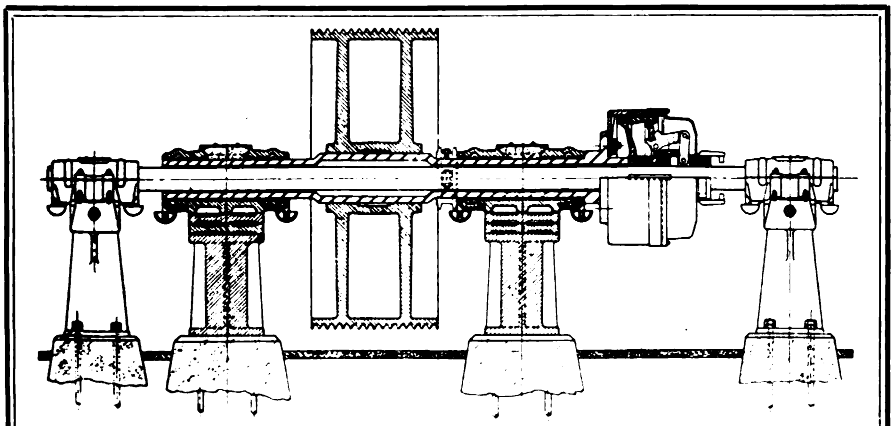
ring is keyed tight to the driving shaft, while the other half with the frustrum of the cone slides on the other shaft with a feather or sliding key. The two halves are engaged by a lever. When this is used as a clutch the ring is usually a part of a loose pulley which is held in place by a collar. Because of the end thrust developed by a single cone this use is generally not so satisfactory. End thrust is one of the chief objections to the single-cone type of clutch or coupling. Another difficulty lies in obtaining the proper slope of the cone; if too flat the jaws may stick and not disengage, while if made with too great an angle it is likely to take hold too suddenly. Also, more pressure (and end thrust) is required to keep the clutch engaged. According to Kent's "Mechanical Engineer's Handbook" this angle usually varies from 7½ deg. to 13 deg. from the horizontal. Single cone clutches are more often used in automotive work than for industrial purposes. These objections, however, are overcome by the double cone-friction clutch illustrated on page 8. The two conical friction surfaces are at a different angle and overcome the above objections.

The friction surface, as on all types of friction clutches and cutoff couplings, may consist of cast iron to cast iron, or cast iron to asbestos, leather, wood block (usually end grain of hard maple), cork insert and special compositions of various manufacturers. The material to be used depends upon the service. If engagements and disengagements are frequent a material must be used which will not overheat easily and stick.

Friction disk cutoff couplings or clutches, as may be seen from the group of illustrations on page 8, apply pressure on both sides of one or more disks or in opposite directions on two or more disks and so eliminate end thrust. The construction of the various types is given in connection with the illustrations and so is not repeated here. With the double application of pressure the action is positive when either engaging or disengaging. Most of these clutches and cutoff couplings, as will be noticed, apply the pressure through a toggle. In some of these it will be noticed that a spring is used to force apart the clamping jaws so as to make a positive disengagement.

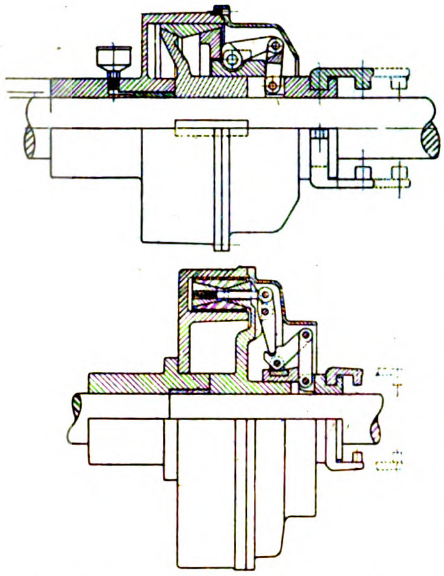
In ring couplings, several types of which are illustrated in this article, clamping action may be applied on the outside or inside of the ring or sometimes on both sides. Also, as in some disk couplings, a V-block clamp fits into a V-ring. This gives a greater friction surface with a narrower ring. The various types of rings, friction clutches and cutoff couplings will also be discussed in connection with the illustrations and so are not repeated here.

In addition to the clamping action several other types of friction couplings and clutches have expanding rings. The expansion is produced



This sketch shows the construction of a quill drive.

When a large pulley or sheave is used on a shaft, it is often mounted on a hollow shaft called a "quill," which is supported on its own bearings. The clutch connects and disconnects the quill. There is no connection between the quill and the shaft except through the clutch. In this way, an entire section of machinery or equipment can be thrown out temporarily or until the driver gets up to speed. The quill may carry either the driver or driven pulley or sheave.



A single- and a double-cone ring-type friction clutch and cutoff coupling.

In this type of clutch, the cone friction surfaces are at two different angles—one steep and the other flatter—which obviates the possibility of sudden seizing or sticking.

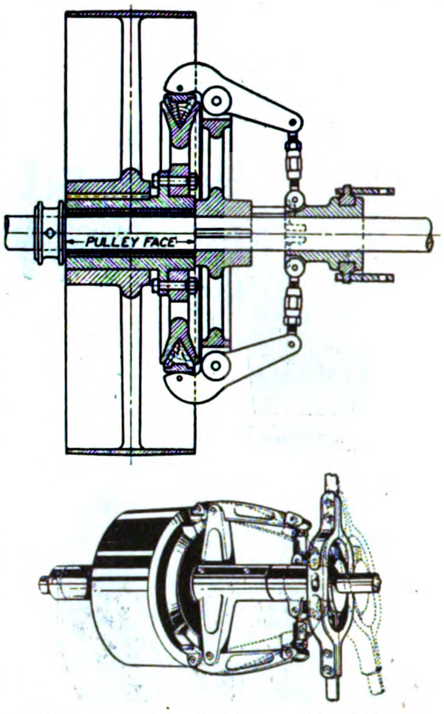
by wedges or dogs, or other various twisting or expansion devices. Friction hub clutches are often used on countershafts.

Countershafts with tight or loose pulleys usually have some form of clutch which may be thrown in and out by the machine operator. Many manufacturers are making the loose pulley and clutch together, as will be noticed from some of the illustrations in this article. Where both forward and reverse operations are required, as on a lathe, these are put in pairs, as shown on page 7.

It is becoming quite common practice to eliminate countershafts entirely on machines with only one driving belt and place clutch pulleys on parallel lineshafts driving down to the row of machines. This not only connects the machines more closely to the driving unit but also reduces the amount of belting required and eliminates countershafts which amounts to a big item in installation and maintenance costs. On the other hand, more lineshaft is required. An interesting pair of illustrations at the head of this article show the difference in appearance and amount of overhead equipment required to be installed and maintained in the two installations. The smaller amount of equipment also means a corresponding decrease in installation cost and in the opportunity for friction, slippage, hot bearings and other power transmission losses.

Each type of friction clutch has a maximum recommended speed which for the ordinary arm clutch is about 400 r.p.m. Other types which are totally enclosed, of small diameter, carefully balanced, well lubricated or ball bearing can operate at high speeds. One manufacturer claims that his equipment will operate up to a circumferential speed of 5,000 ft. per minute. For high speeds, ball bearings are recommended, as they are more easily lubricated and give less trouble from sticking or tight pulleys. Magnetic clutches may also be used at high speeds.

Where the size or weight of a pulley, sheave, gear, or rotor in connection with a friction or jaw clutch is so large as to make it impracticable to mount it on a sleeve, because of insufficient bearing capacity, a quill is often used. A quill, as shown in the illustration on page 7, is a hollow shaft supported by independent bearings. The main driving shaft running through the quill is thus relieved of all transverse stresses, such as the pull of belt or rope and also the weight of the pulley or sheave. The power is transmitted to the quill by means of a friction or a jaw clutch. When the clutch is disengaged and the quill standing still it does not wear as the revolving shaft does not come in contact with the quill at any point. On the other hand, if the quill is revolving with the clutch thrown out and the inner shaft idle, the only wear is in the quill bearing. Jaw clutches are frequently used but only if the speed is low or conditions are such that they can always



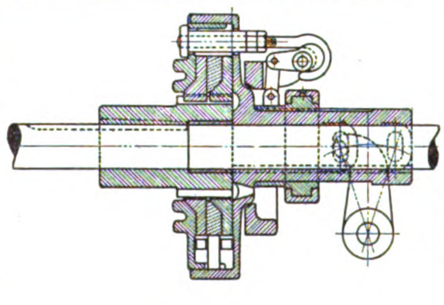
Two types of clutches with V-friction rings.

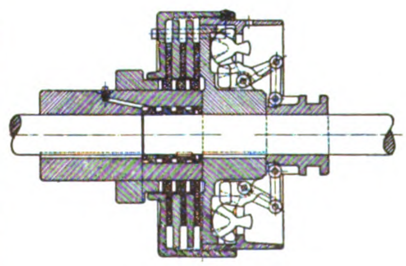
Here the friction block fits into a V-groove. In both cases the pressure is applied by a toggle motion.

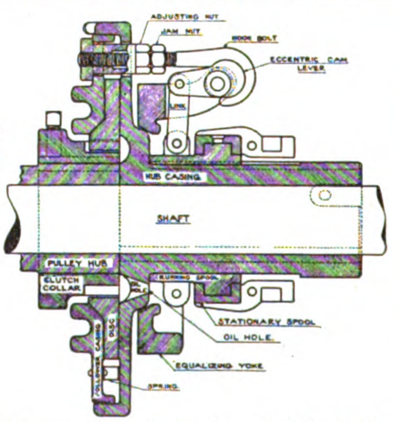
be engaged or disengaged when at rest. Frequently quills are used to connect the driver to the shaft as then the driver can be started up with the clutch out and carrying no load except the slight bearing load of the quill until up to speed when the clutch is thrown in.

Construction and Operation of Magnetic Clutches

In magnetic clutches the friction surfaces are held together by the direct pull of an electromagnet. When the circuit through the electro-

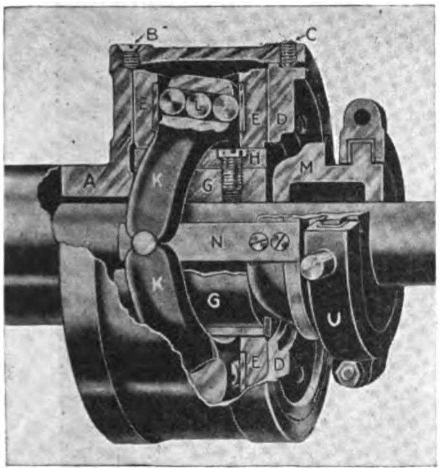


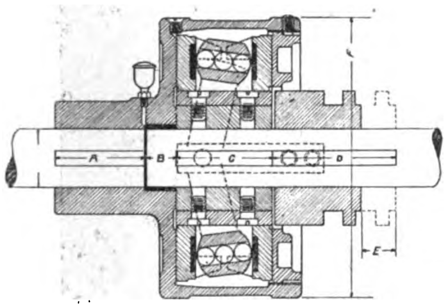




Construction of single-, double- and triple-disk friction clutches and cutoff couplings.

The two sketches at the left show the construction of cutoff couplings, while that at the right is of a pulley clutch. For extra heavy duty some types of clutches have six or more disks.





Here the clamping action is applied through rollers as shown in the sketch and photograph.

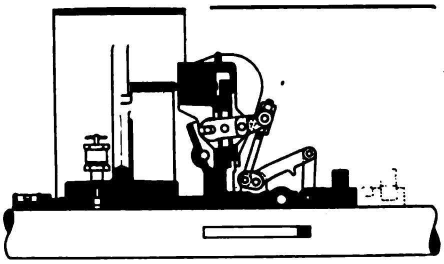
As the clutch is thrown in, the three rollers are forced against the friction surface as shown in the sketch. This clutch is totally enclosed and of comparatively small outside diameter so that it gives low centrifugal action at high speed. Also, with totally enclosed clutches, it is somewhat easier to retain lubrication on the working parts.

magnet is closed, the clutch is engaged; when it is open, the clutch is disengaged. The operation of this clutch is described in connection with the sketch shown below. Some of the advantages claimed for magnetic clutches are: smooth acceleration, ease of operation, elimination of end thrust, and a definite capacity. As it requires a short interval of time for the magnetic action to build up to full strength, the friction surfaces engage gradually and permit enough slip to make a smooth start.

The ease of operation and control is also an important feature as it is only necessary to close or open a switch to engage or disengage the clutch. In this way the control may be handled from almost any position or even at some distance from the mechanism, and may be operated either manually or automatically. It is easier to determine the capacity of a clutch because this is absolutely dependent upon the known pull of the magnet. Also, this capacity is not affected by centrifugal forces which come into play when the magnetic clutches are running at high speed.

Another advantage, particularly where it is necessary to put a clutch in small space, is that it does not occupy as much space on the shaft as some other types. Like other types of clutches, magnetic clutches may be used in connection with a pulley or sheave and may be built in as a part of it. These magnetic clutches are built in sizes from 7 in. to 78 in., in diameter, and may be used to transmit from 1 hp. to 2,000 hp. As with other clutches they are rated according to the capacity transmitted in horsepower per 100 r. p. m.

An article in a later issue will take up practical points in the operation of friction and magnetic clutches and couplings together with the information required when selecting equipment to fit the requirements of certain installations.

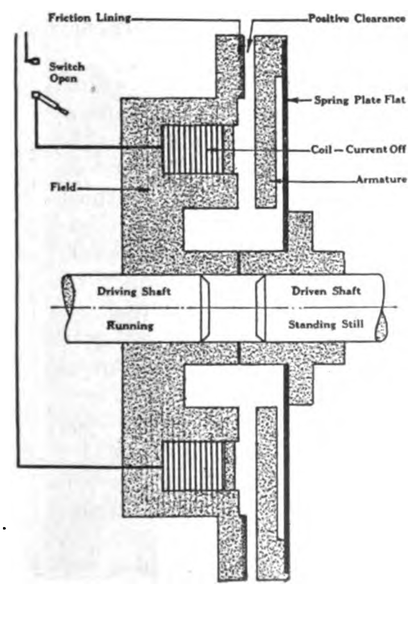


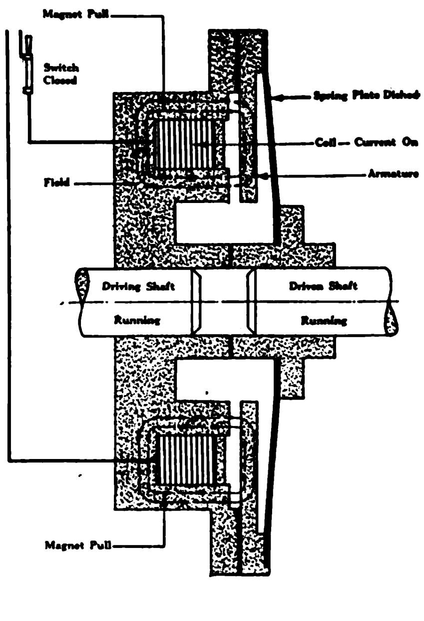
A ring-type friction clutch used in connection with a loose pulley.

Here the friction ring is clamped on both sides through a toggle action which engages and disengages the jaws. The pulley is mounted loose on an extended sleeve which is keyed to the shaft. Ample provision must be made for adequate lubrication.

Diagram showing how a magnetic clutch acts as a cutoff coupling.

The illustration at the left shows the magnetic clutch with the switch open and the magnet de-energized. The driving shaft is running and the driven shaft standing still. When the clutch is energized by throwing in the switch, the magnet pulls the other half of the coupling over until the friction plates are in contact. In this way it picks up the load gradually, as it requires a short time for the magnets to become completely energized, and have both shafts running at full speed. The magnetic action "dishes" the spring steel plate, but as soon as the current is turned off the spring in the plate pulls the flange out of contact and instantaneously disconnects the two parts of the coupling. Electric contact is ordinarily made through collector rings, or slip rings which are mounted on the field hub and are connected to the clutch coils by copper leads. On magnetic clutches, as with all other types of friction clutches, it is essential that the shafts be kept in proper alignment.





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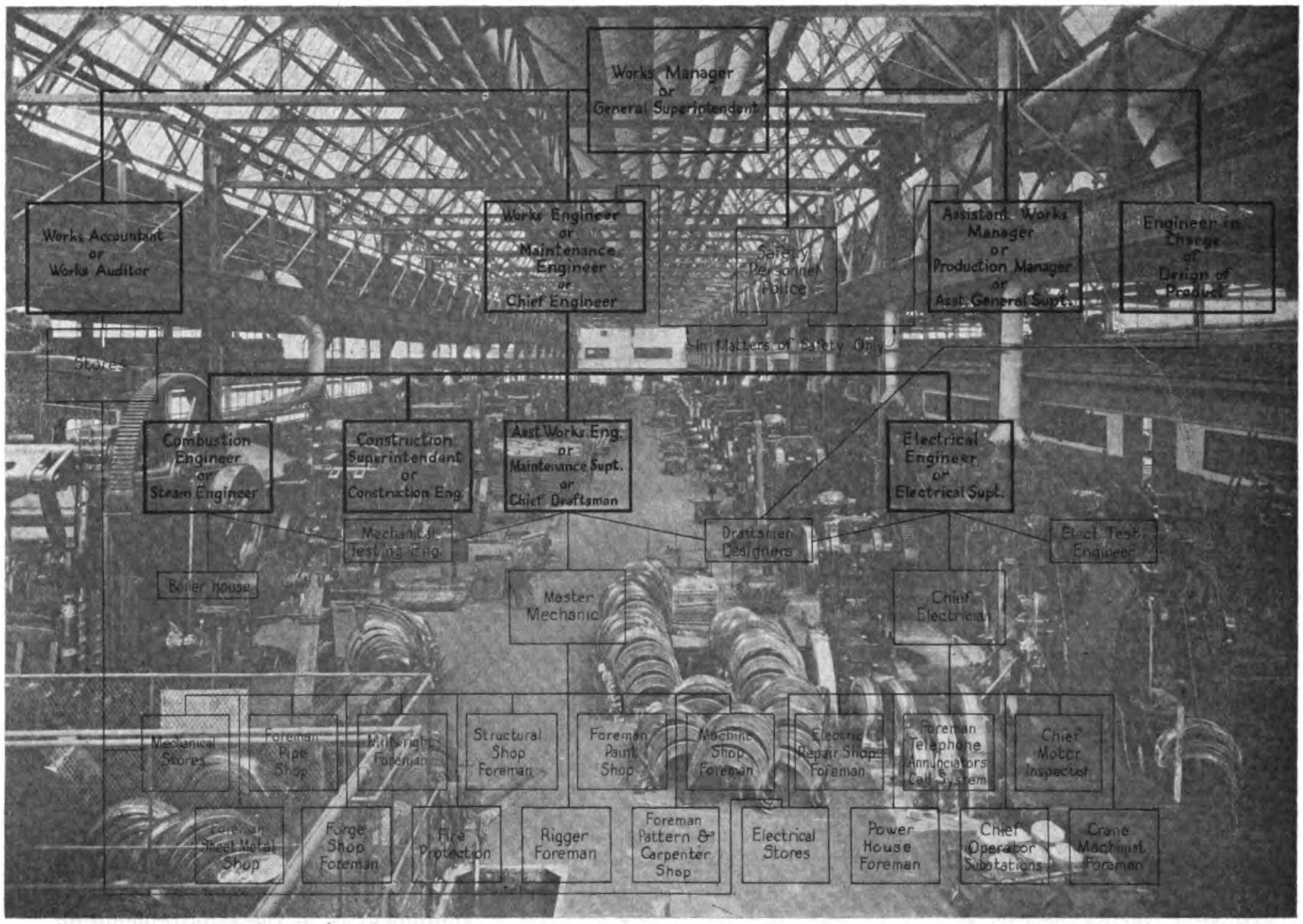


An Analysis of the

Work and Responsibilities of Maintenance Engineers

With Comments by Readers on Divisions of the Work and the Duty Assignments That Have Proven Most Effective

By DANIEL H. BRAYMER

Editorial Director, Industrial Engineer

WHEN INDUSTRIAL ENGINEER was started two years ago as a paper devoted to the operation of electrical and associated mechanical systems in mills and factories we promised to furnish supervising mill engineers and factory department heads who carry the real responsibilities in the operation and maintenance of electrical and associated mechanical systems, practical ideas and information dealing with the fundamentals of good practice rather than theory. In connection with the execution of this editorial plan, issue to issue, we have received the endorsement of hundreds of readers through personal letters and co-operation through suggestions and comments. These communications indicate that much definite thinking is being directed toward operation and maintenance procedure in small as well as large works along the lines that we have laid down for editorial discussion in INDUSTRIAL ENGINEER.

In the larger works where the physical property covers acres of ground and several processes are involved, one depending upon the other, the need for organized effort to prevent interruptions in production or the breakdown of equipment in any one department is obvious. The majority of the larger mills and factories provide a definite organization with well-defined responsibilities in connection with maintenance and operation in all departments of the works. In the smaller mills and factories, however, there is a tendency to keep the wheels turning as long as possible and to take care of maintenance when the emergency arises.

There is, nevertheless, the same need for organized effort in operation and maintenance work in the smaller plant as in the larger one and the results secured in those plants where definite attention has been paid from day-to-day and week-to-week to maintenance in the form of inspection, overhauling and repairs before breakdowns occur, with the idea of anticipating breakdowns and preventing interruptions in production service, have shown the value of this activity through increased production and prevention of losses that accompany interruptions and breakdowns.

In the outline of editorial plan and

scope in the first issue of INDUSTRIAL ENGINEER (January, 1922), the writer analyzed in detail the course of engineering thinking of a technical and research character in the growth of industrial works in this country and pointed out the need for more evidences downward throughout works organizations of a similar application of engineering thinking in operating practices and in the maintenance and operation of the systems that are a part of or auxiliary to manufacturing processes from the standpoint of continuity of service and production costs. Under maintenance is included the upkeep of buildings housing plant equipment and the standards set up for safety to operators and against fire. In this article certain analyses of maintenance work that have already appeared in INDUSTRIAL ENGINEER are summarized to give our readers a broad viewpoint of the work of the maintenance engineers and to point out the phases of it that have been and will be discussed in this publication.

It is generally agreed that engineering work in industrial works can be roughly divided three ways as outlined in the accompanying boxed statement.

In view of fast-growing applications of electric service in industrial works and its close association with the operation of mechanical systems, special editorial consideration is given in INDUSTRIAL ENGINEER to details of service requirements and present practice in meeting them from the viewpoint of the supervising heads responsible for the inspection, overhauling, changing and repairing of the systems involved. In this work both the electrical and mechanical details of the job are discussed. In dealing with any phase of it, a true balance of the practical importance of the electrical and mechanical details are maintained as controlled by the relationship of the electrical and mechanical features that are associated in the operation of any particular mill or factory system.

In this connection INDUSTRIAL ENGINEER is rendering a new and complete service to a group of men who are doing worth-while things and represent a phase of engineering thinking in the operation of American industries that will expand and grow in importance in proportion to the expansion of the physical proportions of industrial works and the added complication of production processes.

Men in charge of works operations in industrial plants are interested these days in production control methods and other ways of keeping production at a maximum in quantity and in economy. They are looking for men who possess imagination, initiative and an ambition to take on the responsibility of executing ideas and plans that will keep works equipment and processes run-

Industrial Engineering Can Be Divided Roughly Into Three Classifications

1. That calling for the technical services of a civil, electrical, mechanical or other professional consultant.

2. That calling for the services of a professional consultant in the analysis or development of industrial processes or phases of management.

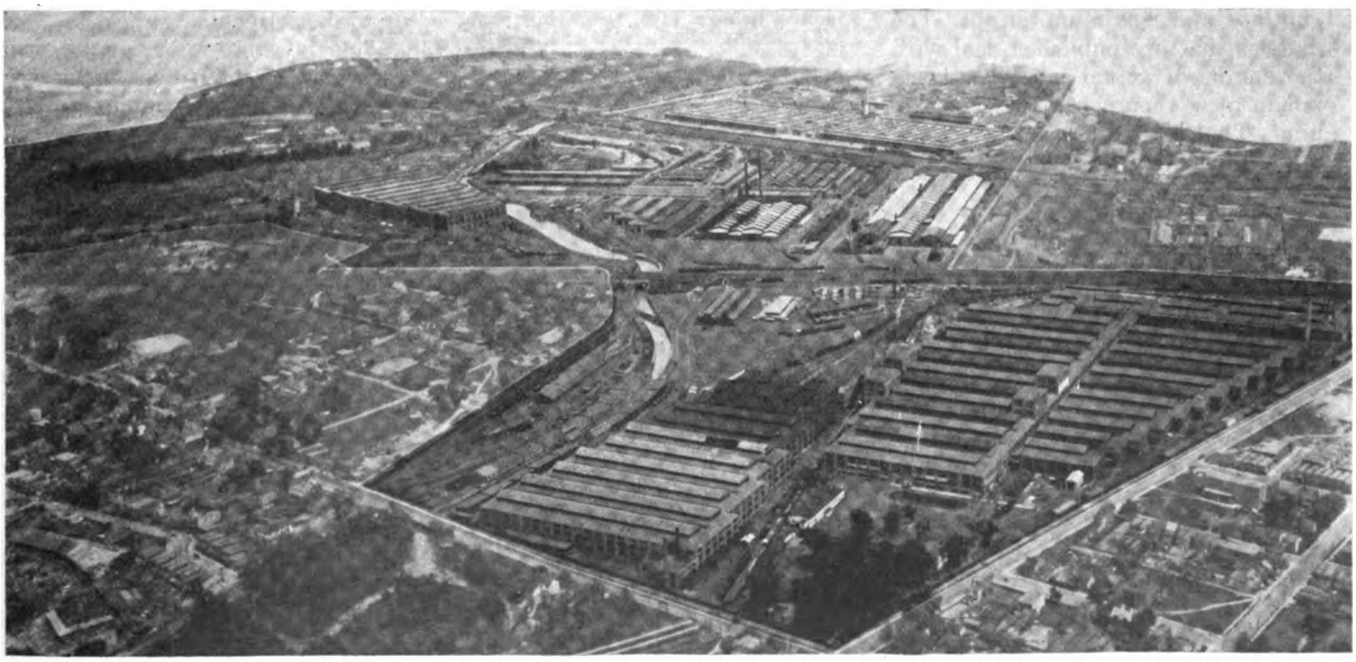
3. That calling for the services of men, in the operating organization of the works, whose training and experience qualify them to be classified among engineers of groups 1 and 2, and also groups of supervisors of work who possess practical experience and the ability to interpret the engineering thinking of their engineer executives and the plans of groups 1 and 2, to modify them as conditions demand, to maintain machine production on an economical basis under changing conditions of plant growth or new requirements with a view to maintaining continuity of service and controlling production costs.

It is to the Industrial Engineers who make up group 3 that this paper is particularly addressed—these men who represent the execution of engineering thinking in the various departments of an industrial works and carry out in a practical way the ideas and ideals of management in the processes of production.

In the past, the work of these men has been in the main a job and we are wrapping this paper around the various phases of that job in such a way as to analyze its practical phases and help them to organize the work on the best lines of engineering practice.

Airplane view of the Eddystone plant of the Baldwin Locomotive Works, located near Philadelphia, Pa.

This plant covers 596 acres. The maintenance department must be able to cover a wide territory and be so organized that a call from any department can be responded to in short order.



ning smoothly, economically and without costly interruptions.

RESPONSIBILITIES OF TWO GROUPS OF MEN IN INDUSTRIAL WORKS

When discussing output of an industrial works, its quality, cost and profit with existing equipment and known labor costs, the thinking of two groups of men is represented. The first group includes those who make up the executive organization and think about production schedules and necessary engineering development and design from the executive viewpoint of translating orders received into products that can be shipped. The second group includes those men who carry the responsibility of executing the ideas of the executives and the engineering force, in the departments of the works that are required to turn out the product from its raw state into its finished form.

This second group of men directly in charge of works operations is interested in production control methods and all other ways of keeping production at a maximum in quantity and in economy. They employ as assistants men who have the ability to carry the responsibility of keeping works equipment and processes running smoothly by correcting faults before they become serious.

The men making up this second group and their assistants are the men to whom INDUSTRIAL ENGINEER is addressed. In fact, INDUSTRIAL ENGINEER is built along the lines of the thinking of these men who are analyzing and laying out production methods from the standpoint of securing better operation, fewer interruptions and maximum output. The articles that are published deal with the details of actual jobs exactly as a man faces them when they come to him. The articles take up the work to be done step by step as it proceeds so that he gets a full, rounded view of the whole problem being discussed because it is presented in exactly the way that he must handle it. Moreover, INDUSTRIAL ENGINEER is furnishing to the plant man who has a supervising responsibility something that will cause him to think more analytically about his work in terms of production.

To those men who supervise work and those who actually carry out its details, INDUSTRIAL ENGINEER is presenting definite analyses of how work is done in different kinds of plants with step-by-step procedure and the results which have been accomplished, together with the methods which have brought these about.

For men responsible for the operation and maintenance of electrical and associated mechanical systems in all industrial works INDUSTRIAL ENGINEER aims to be a handbook of better operating practices and of the ways other men are handling maintenance problems. Moreover, it is their guide to reduced operating costs and the elimination of waste through reduction of costly shutdowns. The problems discussed are those that lie along the path of power service which extends from the point where power service is received in the plant through all the equipment which represents power service up to the driven element of machines engaged in production.

THE PATH OF POWER SERVICE IN INDUSTRIAL WORKS

In this line or path of power service INDUSTRIAL ENGINEER takes up the complete electrical and associated mechanical parts of the units or systems involved. In the case of a motor driving a machine such as a lathe we start at the main switchboard, go through the main and branch electrical circuits and motor control equipment to the motor shaft through the belts, chains or gears to the main and counter shafting, if there be such, and through the belts again to the pulley of the machine that is actually engaged in production and depending upon this path of power service for continuity of operation.

In the case of a conveyor, which again is inserted in the line of power service to machine or to different departments of a plant, we begin at the switchboard and go through all the circuits and control to the motor driving the conveyor and through the chain of mechanisms that the conveyor includes as a unit right up to the point where the service of this conveyor ends and the work starts again on a detail or process of production and is not riding on an element of power service to machines or to departments.

This is what we mean by operation and maintenance of electrical and associated mechanical systems or units in a plant.

Maintenance engineering and pro-

Below is a bird's-eye view of the McCormick Works and Tractor Works of the International Harvester Company in Chicago, Ill.

An electrical or mechanical drive failure in a plant such as this causes a loss in production which not only affects the immediate machine, but may shut down a section of the works before and after the machine, provided the delay is of sufficient duration. The plant illustrated above is devoted to the manufacture of McCormick reaping and harvesting machinery, with the Tractor Works in the distance. The different divisions of this plant are as follows: (1) Works and engineering offices, assembling and finishing rooms; (2) malleable iron foundry; (3) grey iron foundry; (4) paint factory; (5) knife and grinding shop; (6) bolt and nut shop; (7) wheel shop; (8) forge shop; (9) wood shop; (10) finished product warehouses; (11) raw material yards; (12) raw material sheds; (13) twine mill; (14) freight house; (15) locomotive house; (16) tempering shop; (17) spring shop; (18) paint-grinding shop; (19) chemical laboratory; (20) No. 5 warehouse transfer agency; (21) hospital; (22) fire and watch service station; (23) garage; (24) barn; (25) motor truck shed; (26) and (27) replacement parts shipment and storage; (28) oil pump-house; (29) tractor works; (30) clubhouse.

Plant of Brown & Sharpe Mfg. Co., located at Providence, R. I.
Maintenance operations play the same important role in this type of plant as in the continuous-process plants. Although a production delay may not mean a waste of material, the loss in production may be very large.

cedure in industrial works is as long and as broad as the area covered by the structures in which the work of production is carried on. It is as complicated as the equipment and processes that are used, yet it is less organized than the work of production at machines, although it is of equal importance and an essential element in any program of production that aims to be economical from an operative standpoint with avoidable accidents and breakdowns reduced to a minimum.

Details of Duties and Responsibilities of a Maintenance Organization

Based on the studies that the editors of INDUSTRIAL ENGINEER have made personally by visits to plants and by correspondence, we have devised a form of organization and details of duties and responsibilities of men in charge of maintenance work which is presented diagrammatically on pages 10 and 14.

In this connection we would like to point out that an ideal works maintenance organization should:

1. Get the work done.
2. Maintain the plant at its highest efficiency.
3. Function with the least friction with other departments.
4. Be so organized as to directly fix the responsibility for every important job on some one man.

The details of an ideal works maintenance organization may vary somewhat in the different industries, but the general arrangement is somewhat the same for all of them. The head of the factory or works organization is usually known as the Works Manager or General Superintendent. Under his supervision are three main departments:

1. The works maintenance department.
2. The production department.
3. The accounting department.

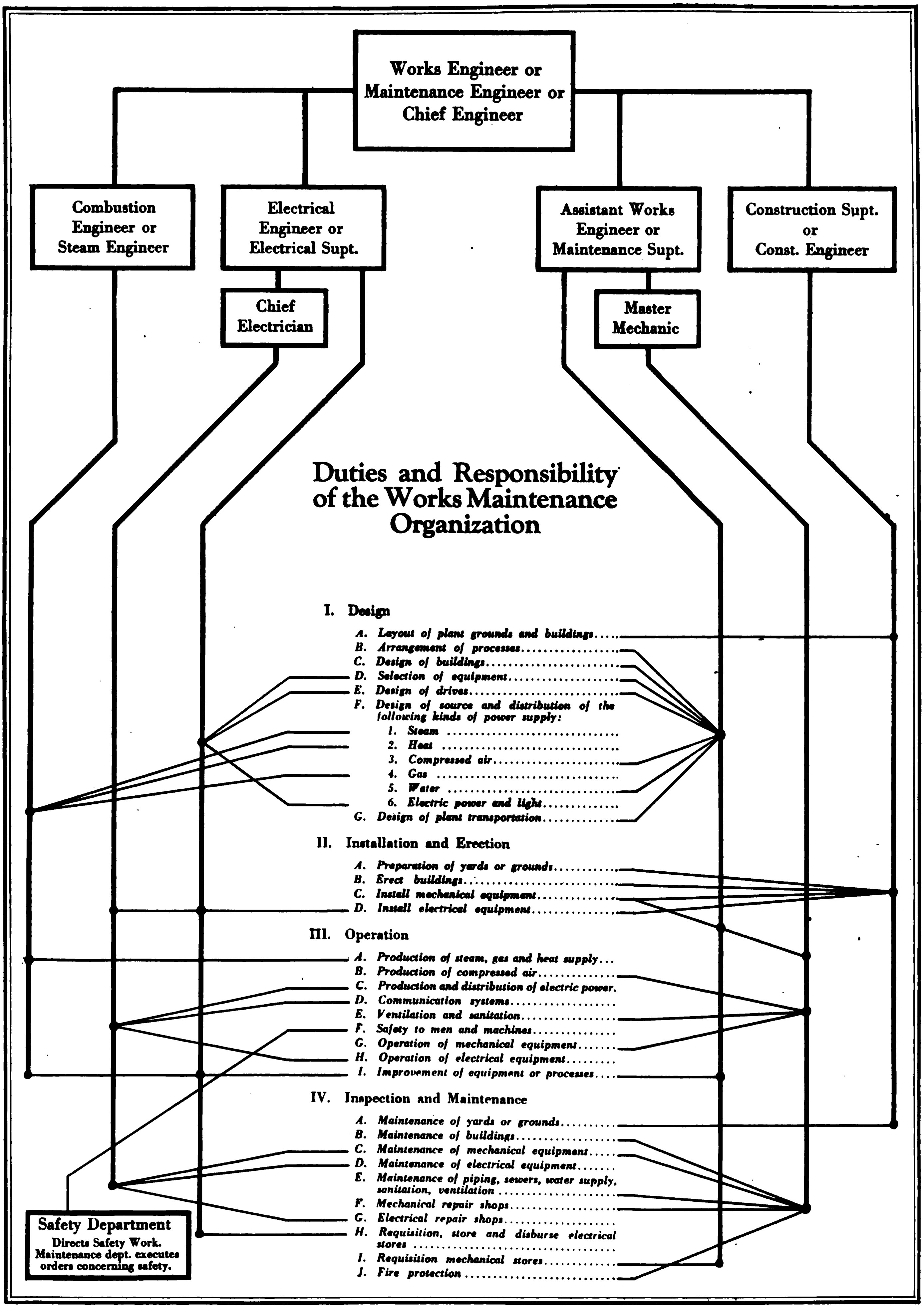
In some industrial works such as the automobile plants and the railway car building factories, there is a fourth department known as the engineering department which has charge of design of the product manufactured. There is also what might be considered a fifth department, the safety department, which does not rank with the rest of the departments, yet reports directly to the Works Manager the same as the other four subdivisions.

The Works Engineer and His Staff

The safety department has charge of all matters pertaining to the safety of machines and employes. This department directs the works maintenance department and the production department in this respect. The maintenance department makes and installs the safeguards and safety devices which are used throughout the plant. The production department enforces the orders of the safety department regarding their use. The safety department quite often is part of a department that also has control of employment and police.

The head of the works maintenance department is usually known

This is the plant of Wm. Cramp & Sons Ship and Engine Building Co., located at Philadelphia, Pa.
Maintenance plays an important part in the continuity of production in a shipyard of this size.


Works Engineer or Maintenance Engineer or Chief Engineer
Combustion Engineer or Steam Engineer
Electrical Engineer or Electrical Supt.
Chief Electrician
Assistant Works Engineer or Maintenance Supt.
Master Mechanic
Construction Supt. or Const. Engineer
Duties and Responsibility of the Works Maintenance Organization
I. Design
A. Layout of plant grounds and buildings
B. Arrangement of processes
C. Design of buildings
D. Selection of equipment
E. Design of drives
F. Design of source and distribution of the following kinds of power supply:
1. Steam
2. Heat
3. Compressed air
4. Gas
5. Water
6. Electric power and light
G. Design of plant transportation
II. Installation and Erection
A. Preparation of yards or grounds
B. Erect buildings
C. Install mechanical equipment
D. Install electrical equipment
III. Operation
A. Production of steam, gas and heat supply
B. Production of compressed air
C. Production and distribution of electric power.
D. Communication systems
E. Ventilation and sanitation
F. Safety to men and machines
G. Operation of mechanical equipment
H. Operation of electrical equipment
I. Improvement of equipment or processes
IV. Inspection and Maintenance
A. Maintenance of yards or grounds
B. Maintenance of buildings
C. Maintenance of mechanical equipment
D. Maintenance of electrical equipment
E. Maintenance of piping, sewers, water supply, sanitation, ventilation
F. Mechanical repair shops
G. Electrical repair shops
H. Requisition, store and disburse electrical stores
I. Requisition mechanical stores
J. Fire protection
Safety Department
Directs Safety Work. Maintenance dept. executes orders concerning safety.

as the Works Engineer, as Maintenance Engineer or as Chief Engineer. Under him are men who function as:

1. Assistant works engineer.
2. Electrical engineer.
3. Construction superintendent.
4. Combustion engineer.

These four men are of the same rank and each has direct control of his own division, subject only to the supervision of the Works Engineer. The organization of the repair shop, maintenance men and power production for each division is shown in the organization diagram.

Under the Assistant Works Engineer are all of the mechanical shops and mechanical maintenance men except the crane machinists. These are under the electrical organization because the most important features of the cranes are electrical and it has been found that more satisfactory operation of the cranes can be obtained by co-ordinating the mechanical and electrical work under the electrical department.

Under the Electrical Engineer come the electric repair shops, motor inspectors, electrical construction men, the plant communication systems, crane maintenance and the electric power generation and distribution.

The Combustion Engineer has charge of the boiler houses. His authority should extend to the steam header in the power house. The steam engines or turbines instead of being under the mechanical department (Assistant Works Engineer) should be under the electrical department. The reason for this is because the electrical department is responsible for the electric power produced, the same as the Combustion Engineer is responsible for the steam power produced. The addition of a third man into the responsibility for power generation merely adds another loophole for "buck passing." Moreover, since a power house engineer is required for handling the work in the power house, it has been found that the best results can be secured by getting a mechanical man with turbine or engine experience and teaching him the necessary electrical knowledge required for handling the power house switchboard operators.

The Construction Superintendent has charge of all construction in a general way. His duties and responsibilities will be detailed later.

The only channel through which the works Auditor comes in direct contact with the mechanical and electrical department is through the handling and use of stores and spare parts. The mechanical department usually requisitions and stores their own spare parts; the ordinary stores are usually requisitioned and stored by the general stores department which is directly under the works Accountant. The electrical department differs from the above in that they not only requisition and store their spare parts, but also requisition, store and disburse all electrical supplies. This is usually necessary because the average help in the storeroom is unfamiliar with the variety of electrical materials and supplies used in maintenance and repair work on industrial equipment.

Main Duties of the Maintenance Organization

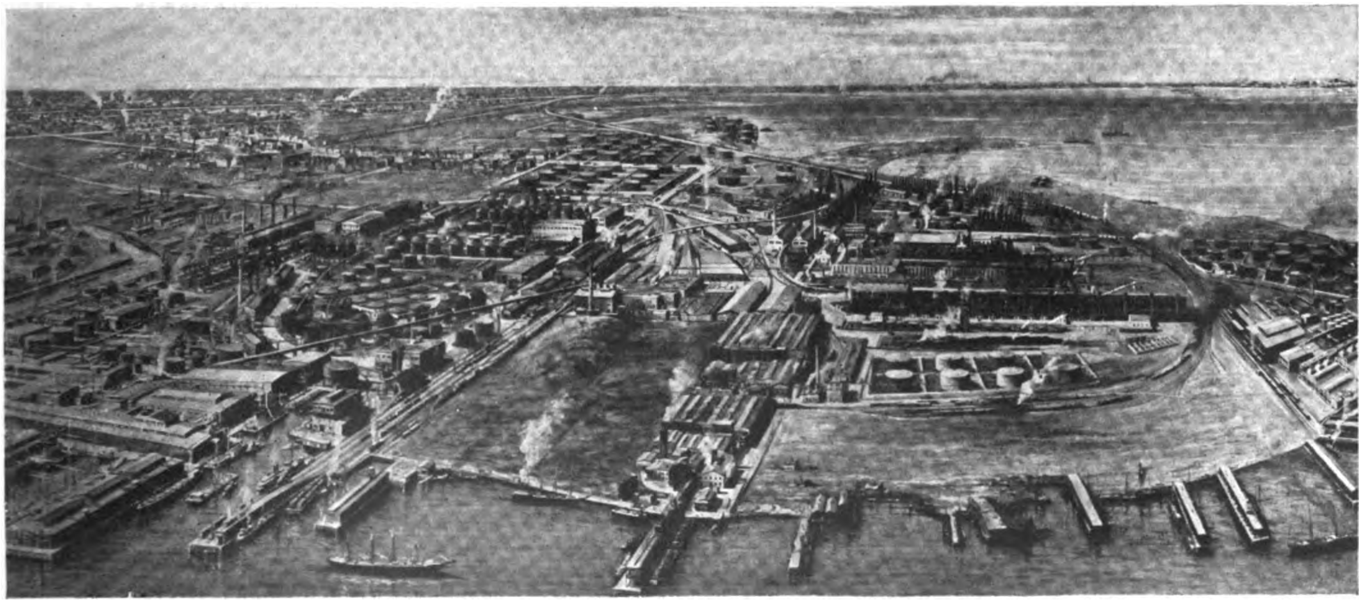
In the diagram of duties and responsibilities the duties of the works maintenance organization are divided among the four department heads who are directly under the Works Engineer. These duties are also subdivided into groups as follows:

1. Design.
2. Installation and erection.
3. Operation.
4. Inspection and maintenance.

It will be noticed that all the four department heads (Electrical Engineer, Assistant Works Engineer, Construction Superintendent and Combustion Engineer) are directly responsible for the design work.

The installation and erection duties are the direct responsibility of the Construction Superintendent. The erection and installation of mechanical and electrical equipment is done by the electrical and mechanical departments under the general supervision of the Construction Superintendent. This supervision is confined to locating the position of the various units of apparatus. The Master Mechanic and Chief Electrician usually do the installation work directly under the supervision of their superiors.

All inspection and maintenance duties except the requisitioning of stores material are the responsibility of the Master Mechanic and the



Six thousand men and women are employed in this Bayonne, N. J., refinery of the Standard Oil Company.
The refining of crude oil is a continuous process. An interruption of the process means a waste of product and if the interruption is of long duration it may endanger not only the equipment but also the lives of the operators. A high order of inspection and maintenance is necessary in a plant of this kind to secure economical production.

Chief Electrician. The requisitions for mechanical and electrical equipment usually originate with the Master Mechanic and Chief Electrician.

The duties and responsibilities of electrical men in industrial work from a production standpoint are for the most part new. The extensive use of electrical service even in our large plants and the revision of mechanical details for such operation, is a product of our present generation of workers, most of whom are still young. And those who have established for themselves jobs that carry recognition have had to fight their way to such recognition. It will not always be so. For management, even when most conservative, places responsibility on those who show results and on this basis maintenance engineers in industrial works have a much brighter future than they may now realize. But nothing will be handed to them on a silver platter—it's results that count and of these there are aplenty that are gradually but forcefully making a dent in the consciousness of industrial executives.

Four Elements of Maintenance and Operation

THE EDITORIAL SERVICE of Industrial Engineer is wrapped around the practical details of everyday jobs. For men responsible for the operation and maintenance of electrical and associated mechanical systems in all industrial works it is their handbook for better operating practices and the ways other men are handling maintenance problems. Under maintenance is included the upkeep of buildings housing these systems and the standards set up for safety to operators and against fire.

Articles in the paper deal with the problems that lie along the path of power service that extends from the point where power service is received in the plant through all the equipment that uses power service up to the pulley of the machine engaged in actual production. In this line or path of power service Industrial Engineer takes up all of the electrical and associated mechanical parts of the systems involved.

MEN IN CHARGE of works operations in industrial plants are interested these days in production control methods and other ways of keeping production at a maximum in quantity and in economy. They are looking for men who possess imagination, initiative and an ambition to take on the responsibility of executing ideas and plans that will keep works equipment and processes running smoothly, economically and without costly interruptions.

In every works the responsibility for production is carried by a group of men—those who supervise work and those who actually carry out its details. To the men on whom this responsibility rests Industrial Engineer is addressed. In fact, Industrial Engineer is built along the lines of the thinking of these men who are analyzing and laying out production methods from the standpoint of securing better operation, fewer interruptions and maximum output.

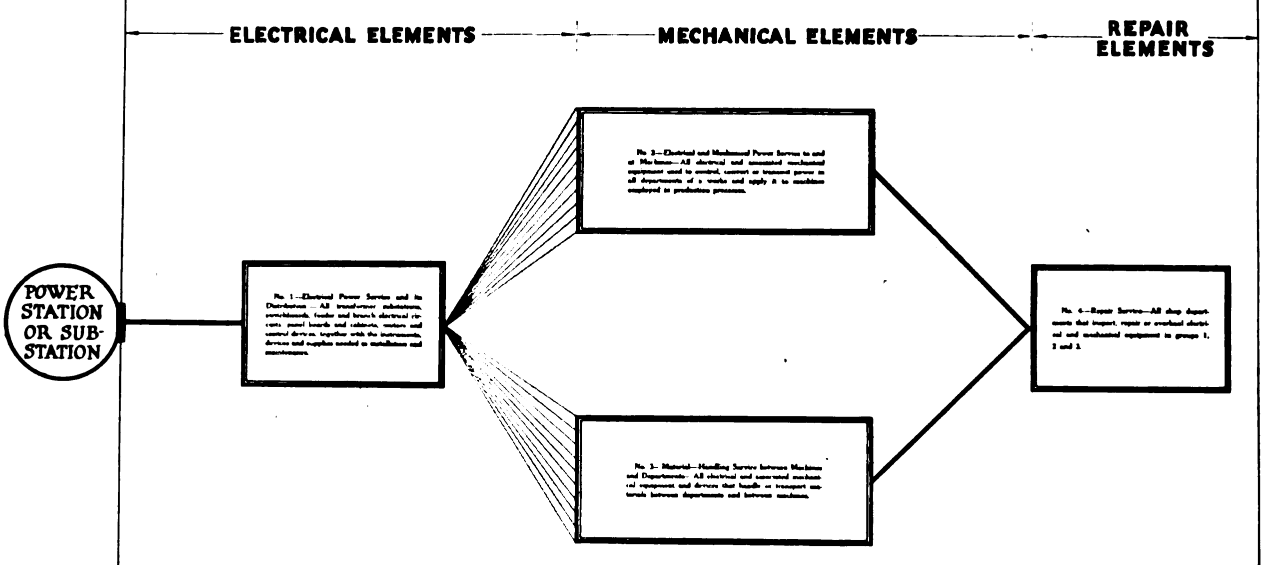
ARTICLES that are published deal with the details of jobs being done day by day. Moreover, Industrial Engineer is furnishing to the plant man who has a supervising responsibility, something that will cause him to think more definitely and analytically about his work in terms of production.

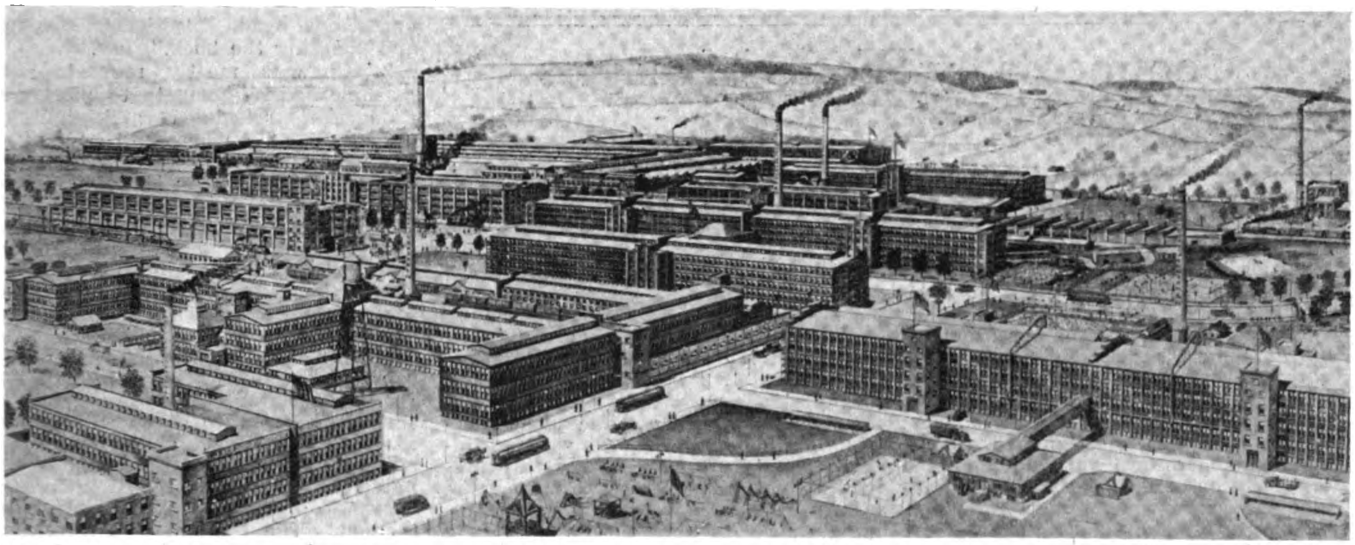
To these groups Industrial Engineer is presenting definite analyses of how work is done in different kinds of plants with step-by-step procedure and the results which have been accomplished together with the methods which have brought these about. It is a handbook of procedure and helps a man who is groping around for practical information to put his hand on something concrete that he can use in doing a job. In brief, the articles presented are written around the practical details of everyday work in industrial plants—such work as installation, inspection, overhauling and repair—and deal with the different phases of these jobs exactly as a man faces them when they come to him in his own plant.

They take up each job step-by-step as he proceeds in the work so that he gets a full, rounded view of the problem which is discussed because it is presented in exactly the way he must handle it.

Editorial Scope of Industrial Engineer in dealing with the maintenance and operation of electrical and associated mechanical systems in Mills and Factories.

The four elements of maintenance and operation discussed along the line of Power Service between substation or plant switchboard and machines engaged in production.





A composite picture of the Endicott-Johnson Corporation's factories at Endicott and Johnson City, N. Y.

In works of this kind, frequent inspection of equipment will greatly reduce repair bills. Particular attention should be paid to inspections when operations cover a wide area and there is a large amount of equipment.

Some Comments on Maintenance Work by Readers of Industrial Engineer

INDUSTRIAL ENGINEER has conducted numerous investigations to determine the procedure and practices now in operation that have been most effective in preventing interruptions in plant service and breakdown of equipment. During the past two months we have written a number of letters to our readers who are Works Managers, General Superintendents, Electrical Superintendents, Chief Electricians, Mechanical Superintendents and Master Mechanics and have studied the problems of plant maintenance, established an organization to carry it on and devised practices which indicate the best procedure to follow. In this connection we have asked the questions shown in the box in the next column.

On the following pages comments are presented from 24 readers of INDUSTRIAL ENGINEER in charge of maintenance in a wide variety of plants. These comments are well summarized in the statement by K. D. Hamilton, Mechanical Engineer of the George E. Keith Company, makers of Walkover shoes at Campello, Mass.:

The duties and responsibilities of the man in charge of the maintenance and plant operation of any well-organized institution are very broad. He should be willing to put his time and energy into solving any problem which may come up, whether it be one of production, one of new construction, or one of maintenance.

The Plant Engineer or Mechanical Engineer in charge of any large plant is responsible for any problem which comes up other than those relating to the direct production problems or policies of the institution. His responsibility covers plant repairs, plant construction, designs, boiler and engine plant equipment and operation, power transmission, electrical as well as mechanical, sprinkler system, fire protection, plumbing department, watchmen and fire alarm systems, safety engineering, machine design, machine maintenance and operation, invention of new processes pertaining directly to the production problem. Anything which comes to his attention should be taken up gladly and given his best attention. The best organization is to have one man responsible for the entire plant. Under him should be the necessary foremen, such as electricians, machinists, millwrights, blacksmiths, steam fitters, carpenters, engineers, etc.

The maintenance organization can show the greatest saving in performing their work at the least cost, keeping the plant in constant operation, and eliminating shutdowns.

> **Questions Asked Readers of Industrial Engineer**
>
> 1. What are the main duties and responsibilities of men in charge of maintenance and plant operation in a well-organized works?
> 2. What lines of work come under their supervision and how can they best organize a force to handle installation, inspection, maintenance and overhauling of electrical and its associated mechanical equipment? In this connection what work can best be handled by the Chief Electrician and what work by the Master Mechanic?
> 3. What kind of changes or rearrangements are men in charge of maintenance most often requested to work out?

The other letters, however, bring up points of interest in connection with maintenance work and definitely show that maintenance engineers have an important field in industrial work where there is a need for more recognition by their executive superiors on the basis of the importance and the value of the work they do in keeping machines running and production flowing smoothly and with a minimum of interruptions due to preventable causes.

Efficient and smoothly running works turning out maximum production on schedule time do not just happen. They are the logical result of the thinking and planning of men whose job it is to prevent all interruptions in machine production and power service. These men can come closer to estimating the effects of natural wear and tear than anyone else in the plant, for they are working with the equipment every day and know its weak and strong points.

Comments by Works Managers and Works Engineers

C. D. Corwin, Works Engineer, Corona Typewriter Co., Inc., Groton, N. Y.: 1. The main duties and responsibilities of men in charge of maintenance and plant operation may be briefly outlined as follows:

Maintenance and plant operation require men of practically every trade with the possible exception of paperhangers and stonesetters. The man in charge of maintenance and plant operation should be broad gauged, for he has as his main duties the selection and organization of the proper men to handle the many diversified problems which go to make up maintenance. He should so organize his force as to properly and efficiently operate the plant and to maintain all of it in first-class condition at all times. He should secure the confidence and co-operation of the men under his charge to the end that every individual will have the company's interest at heart, and will be on a constant lookout to render better service to all departments. He should establish a suitable inspection routine in order to anticipate failures and to make the necessary repairs and adjustments before serious breakdowns can occur. Much money may be saved and much lost time prevented by such regular inspection.

2. The maintenance organization should be responsible for all lines of work in maintaining the entire plant in the most efficient operating condition including the aesthetic and sanitary features. The Chief Electrician can best handle all electrical equipment. The Master Mechanic can best handle all other equipment. It is presumed here that the title Master Mechanic is synonymous with Plant and Works Engineer, and that if the size of the plant demands it there shall be various divisions, each with its foreman, for instance: machinery maintenance, tool maintenance, building maintenance, factory maintenance and safety work, and so forth.

3. Relocation of pipe lines and machinery to better facilitate routing of work are the important and frequent changes made. The maintenance organization should have information on various types of roofs, concrete and brick exteriors, concrete floors, window washing, removal of obnoxious fumes and wastes.

John E. Payne, Works Engineer, American Malleables Company, Owosso, Mich.: 1. I believe that the main duties and responsibilities of men in charge of maintenance and plant operation in a well-organized works, consists mostly of planning new installations, getting better results from existing equipment and systems, planning more economical methods and handling the unexpected problems which arise in all plants and require cool thinking and decisive action.

2. The work which comes under their supervision is highly varied in different plants. Personally, I am responsible for the entire mechanical and electrical equipment, also the buildings. My organization consists of an Assistant Master Mechanic and Chief Electrician, with one man under him, one machinist and helper, two millwrights and helpers as required, one or two electricians and helpers as required, one construction foreman and gang, one head carpenter and assistants as needed, one blacksmith and helper, day and night fireman for heating plant only, plant machinery oiler and plant watchman. When the Master Mechanic and Chief Electrician are under one head, it prevents disputes and "passing the buck."

3. Changes mostly requested are machine rearrangements to meet new production schedules and building changes to meet new conditions.

W. T. Price, Works Manager, Westcott Valve Co., Seneca Falls, N. Y.: 1. The main duties of the men who look after maintenance in our plant are to install all new equipment and keep same in good running order, as well as to keep all machinery, motors and compressors in good running order.

2. We have about thirty-three motors, all started by men appointed to do the starting. The inspection of same is taken care of by the maintenance department, along with the cleaning and oiling. Maintenance department men are directly under the Works Manager or General Superintendent. The General Superintendent does all figuring for changes of every kind, but also advises with the foreman of maintenance department. Repair parts should be kept in stock for all fuses, as well as an extra set of fuses for each fuse box and for motors thrown directly across the line; twelve fuses should be stocked.

Almost all of our motors are protected with overload relays and, also, an automatic controller on the direct line between fuse board and transformers. We have had practically no trouble with our electric equipment in four years.

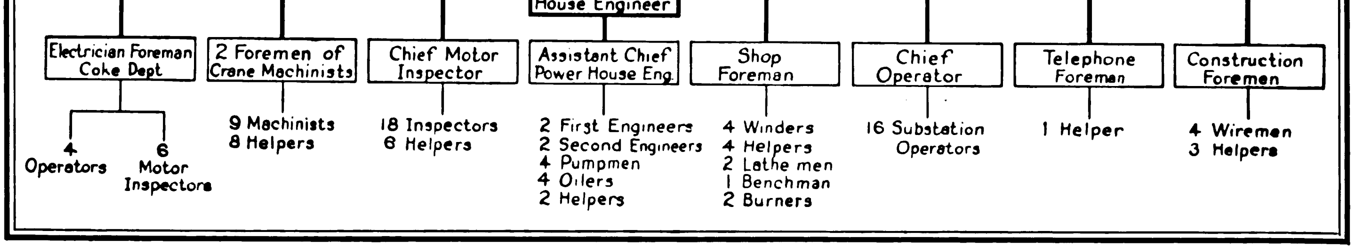
H. B. Emerson, Superintendent, Arlington Mills, Lawrence, Mass.: 1. The main duty of the man in charge of maintenance and plant operation is to keep the plant in condition for the maximum amount of production at a minimum cost.

2. All work pertaining to installation, proper up-keep, effieient operation (including lubrication) and life maintenance, should come under this man's supervision. His force must be organized so as to efficiently take care of the above work at a minimum cost, and to be maintained so that there will be no divided responsibility in the work.

The position of the plant will in a measure decide whether the electrical and mechanical repairs can best be handled by a force within its own organization or by an outside party. In a number of industrial centers outside parties have made a special bid for

Organization chart showing the plan by which the work of the electrical department is supervised.

In addition to the superintendent, his assistant and the office force, the department consists of 112 men. There are ten men who rank as immediate supervisors on the job, and 102 workmen. The construction section is expanded at times to provide for the existing construction requirements. Operators working in the coke department are shown under the authority of the coke department electrician foreman, because the coke department is somewhat removed from the rest of the plant so that the chief operator is at a disadvantage in supervising these men.



such work and owing to the amount of work handled and the specific equipment in their shops, can do better, quicker, and cheaper work than by a force maintained in an individual plant.

The Chief Electrician should take care of all electrical operation and maintenance, calling on the Master Mechanic to do any purely machine repairs. The Master Mechanic should be responsible for all machine installation, operation and maintenance.

3. In a properly designed plant, changes and rearrangements should be unheard of, as a modern plant today is generally laid out with the idea of future increase in a certain direction. In old plants all kinds of changes and rearrangements to facilitate production must be made and the man in charge of maintenance will undoubtedly be asked to help work out these special problems.

An industrial engineer must be as resourceful in maintenance methods as a country doctor is in diseases of the body and mind and must, as does the country doctor, diagnose each individual case and then apply the proper remedies to get the best results.

Comments by Mechanical Engineers and Master Mechanics

K. D. Hamilton, Mechanical Engineer, Geo. E. Keith Co. (Makers of Walk-Over Shoes), Campello, Mass.: To answer all of the questions which you have mentioned in the detail in which they should be answered would require several pages of typewritten matter.

1. The duties and responsibilities of the man in charge of maintenance and plant operation in any well-organized institution are very broad. He should be willing to put his time and energy into solving any problem which may come up, whether it be one of production, one of new construction, or one of maintenance.

2. The Plant Engineer or Mechanical Engineer in charge of any large plant is responsible for any problem which comes up other than relating to the direct production problem or policies of the institution. His responsibility covers plant repairs, plant construction, designs, boiler and engine plant equipment and operation, power transmission, electrical as well as mechanical, sprinkler system, fire protection, plumbing department, watchman and fire alarm systems, safety engineering, machine design, machine maintenance and operation, invention of new processes pertaining directly to the production problem. Anything which comes to his attention should be taken gladly and given his best attention. The best organization is to have one man responsible for the entire plant. Under him should be the necessary foremen, such as electricians, machinists, millwrights, blacksmiths, steam fitters, carpenters, engineers, draftsmen, and so on.

3. The maintenance organization can show the greatest saving in performing its work at the least cost, keeping the plant in constant operation and eliminating shut-downs. The greatest direct saving can be made in the reduction of power and fuel bills.

4. The changes and re-arrangements of problems presented to men in maintenance work are many. Most of them are machine details, new construction and power plant work. INDUSTRIAL ENGINEER can help in attacking any one of the various phases of the maintenance engineer's work and pointing out certain practices used in large industrial plants.

J. P. Hines, Master Mechanic, Lever Brothers Company (Makers of Lux, Rinso, Lifebuoy, Pear's and other soaps), Cambridge, Mass.: Your letter asking for comments on various subjects is at hand and I take pleasure in submitting the following, trusting that you may be assisted by it in compiling data which will go to show that maintenance engineers have an important field in industry; also to show the need for giving the maintenance engineer more recognition on the basis of the importance and value of the work that he does.

The main duties and responsibilities of men in charge of maintenance and plant operation in a well-organized works are as follows:

1. To keep the plant in a running condition at all times.
2. To lay out new installations.
3. To advise regarding the increasing or decreasing of the number of employees coming under their supervision.
4. To study the products with the idea of simplifying their process of manufacture both from a cost and from a production standpoint.
5. To advise regarding the selection of new equipment to be installed in order to determine the best and most economical types to meet the conditions.
6. To make a study at all times of every possible precaution to safeguard both the machinery and operator from injury.
7. To keep accurate records from day to day of the major happenings of the plant's operations, such as power, water and gas consumption, accidents, and the like. These records will often prove of invaluable service in settling questions of future development as well as placing the responsibility for past happenings.

The principal work coming under the supervision of the maintenance organization is: repairs, new installations and plans for future expansion.

At our plant we have a Master Mechanic who reports directly to the Plant Engineer, to whom he is directly responsible. His duties are to handle all new installations, inspections, general maintenance, and overhauling of electrical and mechanical equipment. Directly under the Master Mechanic comes his staff of assistants, consisting of chief draftsman, foreman steamfitter, foreman carpenter, chief electrician, foreman machinist, chief engineer of the power house, and head janitor. It is the duty of each of these assistants to carry out such orders as come under their individual departments, such orders originating in the Master Mechanic's office. The Master Mechanic supervises the work of each department and gives his final O. K. when such work has been completed satisfactorily.

A well-organized repair force in a plant can, to my mind, make the greatest saving to the organization. Repairs are generally looked upon as a source of expense and in most works are put off until the last moment. If an actual breakdown occurs the more efficient the maintenance organization the quicker the wheels can be started again. It is much better, however, for all concerned if the breakdown does not occur, and the practice we adopt at our plant is to make a thorough inspection of machinery whenever the opportunity presents itself. If parts are found badly worn they are taken out and replaced. Sometimes a part can be repaired and made as good as new. This part can then be held for a spare. **An invaluable asset to the maintenance organization is to have in charge those who know when parts should be repaired and when they should be discarded and replaced for new ones.** Many times perfectly good parts are discarded by the inexperienced when they could be readily repaired. On the other hand it is quite often the case that valuable time is lost trying to repair parts that can be purchased new for half the money.

The kind of changes or re-arrangements that men in charge of maintenance are most often requested to work out should be grouped under four heads as follows: 1. Changes due to growth or expansion. 2. Changes for improving the quality of the product. 3. Changes for shortening the process of manufacture. 4. Changes to make way for future development.

Geo. S. Neeley, Master Mechanic, International Shoe Co., S. Wood River, Ill.: 1. The duties and responsibilities of our maintenance department cover everything and anything, mechanical or electrical, that could arise in a plant of the size and character of this one. 2. The installation of motors, replacements, removals of bearings, inspection of motor drives, chains and sprockets for alignment and lubrication, tests for grounds and removing of same, installation and maintenance of lighting system, are duties that are assigned to the first electrician and a helper. Where the work involved is purely mechanical, the electrician usually turns this part of the work over to the mechanics of the department but stays on the job until every item of work is complete and all apparatus is in normal service.

As Master Mechanic, I do not interfere in regular routine repair work unless results are not as rapid as the circumstances would seem to warrant. I have been able to develop better initiative in repair men by making it a practice not to interfere with the men when once they have a clear layout as to what is required. I happen to possess a rich experience in both electrical and mechanical lines, and therefore keep in close touch with all branches of new and maintenance work involving these lines of endeavor. This is evidenced in our output which is easily 75 per cent more than the institution was de-

signed to produce, as against only a little more than one-fourth its capacity four years ago, which was the best they could get out of the plant under the conditions that then existed.

3. As head of the maintenance department of this plant, I have had a hand in working out many details of operation that have resulted in such advantages that patents have been applied for in order to protect the ideas involved. A good maintenance department can do wonders for any industrial plant, by close observation and applying common-sense, tried-out, mechanical-electrical methods. The job is generally what the head of the department chooses to make of it—he can easily make it so efficient that every other department really leans upon him for counsel and support; or he can so conduct his department that the reverse of this is true. I have seen both types in operation.

4. Our line of maintenance is a little different from the average, owing to the greater variety of leather-working machinery in use throughout this type of plant. We can apply anything in the electrical and mechanical lines that suits our case, but, usually our immediate requirements lie in a field outside these two lines.

H. W. Hill, Master Mechanic, Anderson Foundry & Machine Co., Anderson, Ind.: 1. The duties and responsibilities of maintenance men vary so much in different plants that it would be a hard matter to establish a standard. Each chief that I have worked under has had different ideas, but my main idea is this: When a large installation or change is contemplated take all men concerned into consultation and see that new plans are satisfactory to every one concerned. I had the pleasure of trying that in one factory with great results. To sum it up in one word, it is—co-operation!

2. In our plant we have two electricians, two millwrights, one belt and lineshaft man, and three helpers, one of whom does winding in spare time.

Albert M. Shatto, Cleveland, Ohio: I have found that to gain headway in any plant requires a lot of co-operation by all employes. The Master Mechanic who has the best interests of his company at heart is always planning something better for the future. If a certain machine is not giving the required service he finds the cause. If a belt drive is the cause of trouble he will try a silent chain or a direct-gear drive. If the cast-iron pinion does not stand the strain he orders cast steel or a steel machined one and so on until the proper one is found to do the work and stand the required strain. And what is true of a machine is true in all factory lines from its foundation to the top of the building.

He should know the place to use wood in construction and the proper place to use steel, brick, stone or cement and have a working knowledge of the different materials. He should have men at his command who can go into any branch of his factory and make repairs according to his instructions. The Master Mechanic is the one who is always looked to, to keep the wheels going and the first one to be called upon when they stop. He is always checking up on new parts for machines, so that if anything breaks he has the new part to put in and continue production.

The duties of the Chief Electrician, as I understand them, are to have full charge of all electrical equipment. He should keep a check on all stock required for his department. His personal supervision should be respected and his effort to keep things in the best condition should have the co-operation at all times of the Master Mechanic. In putting in new machines the Chief Electrician should always see that condulets are properly placed and after foundations are finished that nothing will interfere with setting of motors or other equipment.

The kind of changes that men are required to work out deal largely with handling of materials. Today everything must be elevated and conveyed by car or track system. Elevators are driven either by belt or sprocket chain and we must find the best type for the material to be handled. If the material is too plastic and fills the elevator buckets and can not be thrown out at the discharge end, then we must turn to something that will handle the material such as the drag flight conveyor of proper design.

INDUSTRIAL ENGINEER can best serve its purpose by publishing articles on handling machine parts in construction work and repairs of all kinds, as well as articles on new equipment, setting forth the most up-to-date method of handling and doing things.

Comments by Electrical Engineers and Chief Electricians

Philip C. Jones, Electrical Engineer, The Goodyear Tire & Rubber Company, Akron, Ohio: There are at least two distinct systems of maintenance. With one method machines are allowed to run with no attention other than oiling until they break down. Then an order is put in and they are repaired. With the other system, machinery is periodically inspected and small repairs made constantly with the intention of never having a breakdown. Both of these systems may have modifications. Excepting such as power house equipment where it is necessary to keep equipment in service regardless of cost, it is an open question as to which of these systems is the most desirable. A minimum overall maintenance cost is the criterion. Discussion of these two systems, particularly if backed up by cost data, would be very valuable. Then, too, data from various sources on cost of rewinding, cost of changing bearings, life of bearings, use of ball bearings or other anti-friction bearings, would be of much help to men responsible for the operation and maintenance of electrical and mechanical equipment.

Robert Drake, Electrical Engineer, McCormick Works, International Harvester Co., Chicago, Ill.: 1. My experience has been in large plants. Beside the routine inspection and maintenance of steam, water, electric, gas and other equipment, the really successful chief trains his organization, from motor inspectors up, to try to study out the cause of trouble and devise an alteration which will make recurrence impossible on the second breakdown of any one general type. If the gang foreman has constructive ideas he should come to the chief or his assistant with them. If he can't see a solution, but realizes that two or three delays have happened from the same cause, he should be trained to call attention to the fact and give someone else a chance to work out a solution.

Of course, no one can work out a solution for ordinary wear, burned fingers and the like, but these things should not cause delays for they can be taken care of by routine inspection at periods of about 60 per cent average life with complete replacement of worn parts at 60 per cent life to give a margin. This is cheaper than trying to get more life out of parts by "watching them and running them a little while longer." Such an idea of the chief's duties requires a testing and drafting force under his direction.

2. Division of work between Electrical Engineer and Master Mechanic can seldom be made according to a set schedule of duties except during the tenure of one man. The division varies with the ability, aptitude and previous experience of the incumbents. The Works Superintendent who alters this division to put the work in the "doubtful zone" onto the man best fitted to do it gets best results, assuming, of course, that a man who has risen to be Superintendent of a large works has enough diplomacy to do this without arousing jealousy. In dividing work it is always best to try to arrange it so that all the duties of any one foreman comes under one or the other head.

3. In my experience, maintenance and design of new construction and alterations come under one head. So far as maintenance foremen are concerned item (3) is answered under (2).

4. So few maintenance departments have a regular system of routine maintenance and inspection of miscellaneous equipment other than motors, starters, etc., that a description of how to build up such a system, how to carry it on and determine periods of inspection, and other details, might be of interest. This is not at all the most useful thing possible, I suppose, but it occurs to me because of the interest shown by plant engineers visiting our system.

5. The matter of greatest novelty which occurs to me is a long story. It refers to a practical method of testing a.c. motors without a wattmeter and in much shorter time.

F. A. Wiley, Electrical Engineer, South Chicago, Ill.: 1. The main duty of men in charge of maintenance and plant operation in a well-organized works is to keep the plant running, at all costs. Incidental to that is maintenance of equipment to reduce as much as possible unavoidable loss of production and to keep depreciation low. It is also their duty to maintain a stock of spare parts and spare apparatus to take care of any *(Continued on page 47)*

A portion of the yard of the Reclamation Plant, where heavy iron and steel scrap is sorted and piled according to the classification of the material. The crane in the center is of the crawler type; it is driven by a gasoline engine and handles the sorted scrap. The two locomotive cranes are equipped with magnets and are used for loading and unloading cars.

Here Are Some Details of a

Reclamation Plant for Miscellaneous Equipment

Where Discarded and Broken-Down Equipment Is Rebuilt and Scrap Is Put Into Usable or Salable Form

By R. K. GRAHAM

General Superintendent, Reclamation Plant, The Atchison, Topeka and Santa Fe Railway Co., Corwith, Ill.

ORGANIZED maintenance work is essential in order to keep equipment in proper operating condition and secure from it the maximum possible service. A well-planned routine for handling equipment and material which have outlived their usefulness, in the ordinary sense of the term, and are considered as junk, will also pay good dividends as we have found by experience.

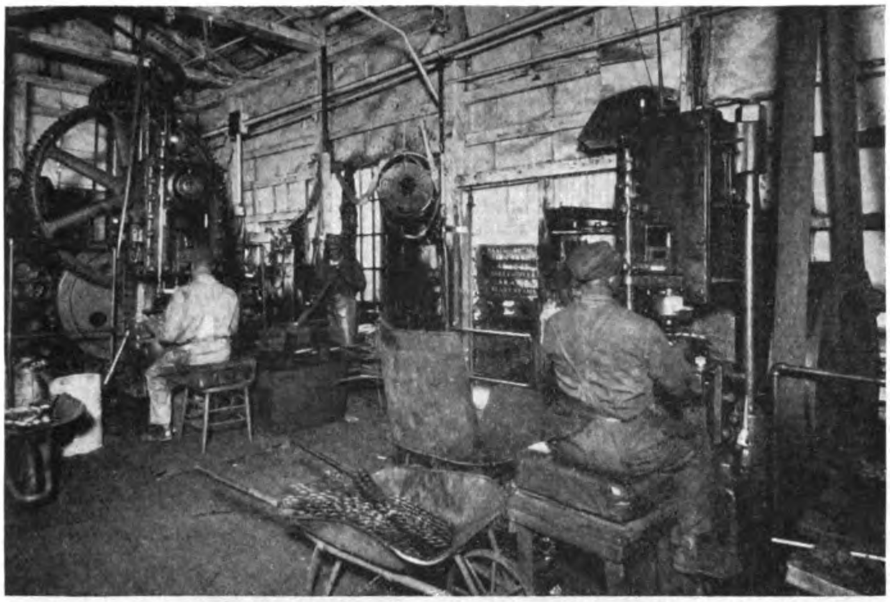
A very large amount of waste and scrap material comprising ferrous and non-ferrous metal scrap, worn or broken parts, car roofing and so on is derived in the course of a year from a railway system which operates 2,102 locomotives and 80,535 passenger and freight cars over 11,706 miles of track. In the shops of the Santa Fe line the work of keeping the rolling stock in first-class condition has always been well organized and executed, but until 14 years ago little or no attempt was made to reclaim material considered to be beyond repair. Much study showed that a good deal of material which we were selling as scrap could be reclaimed or worked into other usable forms at comparatively small cost. A portion of what is officially known as the Corwith yard, on the south side of Chicago, was finally set aside and an appropriation of $65,000 was made to provide buildings and working capital for a plant in which this work could be done. The original shop was a dismantled box car.

The reclamation plant at Corwith now covers twenty-six acres of ground and comprises two large, brick buildings and a number of large and small steel-frame buildings covered with sheet-iron.

In keeping with its object, the plant as a whole has been constructed almost entirely of junk or waste material. That is, the brick buildings were built of bricks which were picked up along the right-of-way in cleaning up the yards, or salvaged from other buildings or structures which have been altered or torn down. The mortar was made from the slaked lime which is a by-product of our acetylene-generating plant. When mixed with a small amount of cement this lime makes very satisfactory mortar and costs us practically nothing.

The steel framework of the buildings which house the various departments of the plant was fabricated from the beams and other structural shapes of old bridges and buildings. The sheet-iron roofing from wrecked or dismantled freight cars was used for the roofs and sides of the buildings. This, too, was scrap material which cost us practically nothing, but was entirely satisfactory for our purpose.

Again, the steel body of a discarded gasoline motor car was placed on a brick foundation and fitted up with showerbaths and lockers for the use of the rolling mill crew.



Old boiler tubes are flattened and cut into washers in this department.

A small set of rolls, not shown here, is used to flatten old locomotive boiler tubes after these have been cut into lengths suitable for handling. Two washers are thus cut at each stroke of the plungers of the presses shown here.

There are six main departments: valve shop; hose department; tinshop; blacksmith shop; bolt shop, and rolling mill. With the exception of the rolling mill the various departments are all equipped with lathes, drill presses, and other power tools which are needed for the processes to be described later on. In the rolling mill we have in operation a 9-in. mill, driven by a 300-hp. steam engine and a 12-in. mill driven by a 500-hp. engine. These mills will roll round material up to 2 in. diameter and flat stock up to 1 in. by 5 in. A good deal of miscellaneous cutting and welding is done both in the shops and in the yard by means of the oxy-acetylene torch. To supply these torches there is a central acetylene-generating station which has a rated capacity of 800 cu. ft. of gas per hr. From this station, both acetylene gas and oxygen are piped, at 9 oz. and 50 lb. pressure respectively, to the different shops and to numerous outlets in the yard, a total of thirty-six stations. The torches used for exterior work are connected to these outlets by lengths of rubber hose usually 100 ft. long. By this arrangement we are able to use acetylene at any desired location for cutting or welding without having to transport gas holders from place to place by means of hand trucks, as is often done.

Air brake equipment and valves are reclaimed in this department.

All air brake equipment and valves which come in are taken apart and washed in the cleaning tank shown at the left. They are then carefully inspected, any worn or broken parts replaced, tested and sent to stock. The testing benches for air brake equipment were designed and built in the shop. The two valve-grinding machines shown in the right background were also designed and built here.

For unloading cars and handling the large amount of scrap material which comes to this plant, there are available four type G, Industrial Works locomotive cranes and one Brownhoist crane. Three of these cranes are fitted with electro-magnets. Direct current for the magnets is obtained from a motor-generator set and conducted through an underground distribution system to a number of outlets fitted with Ralco, No. 9 power receptacles and located at intervals alongside the tracks. From the outlets current is conducted to the magnets on the cranes by a 200-ft. length of cable. In addition there is a gasoline-engine-driven, Industrial Works crawler-type crane which is used for piling sorted scrap and for other work of like nature around the yard.

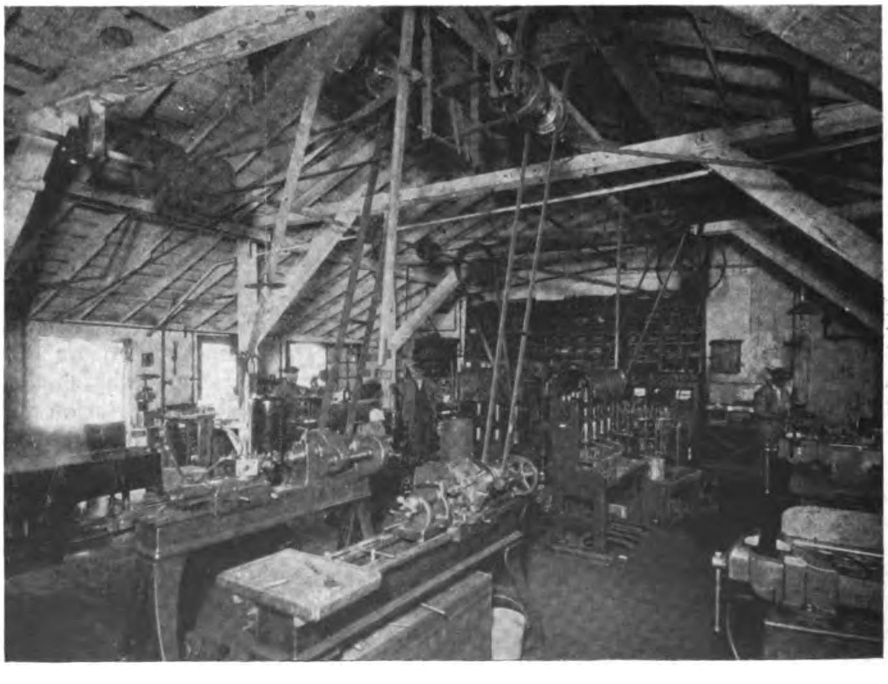
By the use of these cranes we feel that we have cut our material-handling costs to a minimum, considering the nature of the material and the operating conditions.

Scrap or waste material which we receive comes from the different division points of the entire Santa Fe system and is of the most varied nature, consisting as it does of all kinds of iron and steel, brass, copper and other scrap, discarded tools and equipment such as shovels, picks, track drills and lanterns, all kinds of air and steam valves, hose, paper, felt, glass, and so on, through the long list of equipment and material used by a large railway system. Although the material which we receive has been discarded as unusable in its present form, not all of it can be classified as junk: that is, as merely so many pounds of iron, brass and so on which will have to be remelted and worked into new products. A convenient and fairly accurate classification would be:

(1) Equipment and parts which can be repaired or otherwise treated to make them usable, at a reasonable cost.

(2) Material which can be worked into other forms at comparatively small cost.

(3) Material which is in such condition or of such nature that it can-



The tin shop turns old car roofing into pails, oil and waste cans and coal buckets.

The roofing on freight cars is made of about 24-gage galvanized iron. When cars are wrecked or dismantled the roofing is removed and sent to this department where it is cut and formed into oil cans, buckets, and other useful articles.

not readily be put into any useful form and therefore possesses only a scrap value.

It is our job to determine to which of these classes the various items and kinds of material belong and then treat them in such manner that a useful product can be made at a profit or, in the case of scrap material, properly prepare it so that it can be sold at the highest market price.

We receive and handle from ten to twenty carloads of miscellaneous discarded material a day, or about 8,000 tons a month.

All incoming material is weighed and the cars are then switched to the different unloading points, depending on the nature of the material which they contain. That is, brass and other non-ferrous scrap is unloaded at one place; heavy iron is unloaded at another place, and so on. After unloading, all of the material is carefully sorted out and the different classes or items placed by themselves. All of this is, of course, merely the first step in our work. The succeeding steps depend, as was stated before, on the nature of the material. Referring to the classification which was made previously, certain kinds of equipment and parts are worked over and put into usable condition. For example, trainmens' lanterns are thoroughly cleaned, bent or broken parts straightened or replaced, new globes put in if necessary, and finally sent back to stock just as good as new in every way. Shovels and forks are straightened and fitted with new handles. Tamping picks likewise are dressed and tempered and new handles put in, whenever necessary.

Steam and air valves are washed to remove all grease and dirt and are then taken apart and carefully inspected for wear and defects. Wheels, stems, packing nuts or other parts that may be broken or worn are replaced and the threads are retapped if necessary. The valves are then given a rigorous test and if they stand up satisfactorily they are sent to stock. In the same way ells, tees and other fittings are washed, the threads recut if necessary and after careful inspection sent to stock. Air brake equipment is thoroughly overhauled and inspected and tested with great care before it is returned to service.

In the case of wheelbarrows, frames are straightened, new wheels put in, if necessary, rivets tightened and any other needed repairs made. Track spikes are straightened by an air-driven hammer, similar to a small steam hammer, and then tumbled to remove all rust. Nuts are rethreaded. Bolts are straightened, if bent, and rethreaded. If the threaded portion is badly battered the bolt is cut to a shorter length and threaded. Truck and body bolsters which have cracked in service or been damaged in wrecks are welded with the oxy-acetylene torch, and after being annealed to relieve stresses, are returned to service. The list of equipment and parts which are repaired and returned to service covers a large number of items.

The second group in the classification covers material and parts which can be worked into other forms. As an example, old locomotive boiler tubes are cut into suitable lengths, flattened in a set of rolls and cut up into washers of various sizes. Likewise the heavy galvanized-iron roofing which is taken from wrecked or dismantled freight cars eventually goes to the tinshop where it is cleaned and formed into large oil cans, pails, coal buckets and so on.

Discarded pipe is cut into short lengths which are threaded to make nipples and couplings. Old car springs which are not of standard type are heated to a high temperature, uncoiled by pulling them in a specially designed machine and cut into short lengths, which are then made into nail pullers and light pinch bars.

A good deal of the round and flat wrought-iron material which comes to us is cut into short lengths and then made into bundles or fagots, heated to a welding temperature and rolled into round or flat bars in our rolling mill. From 60,000 lb. to 90,000 lb. are rolled a day. The round bars are made into car and engine forgings, bolts of various sizes, chains and so on. The flat material goes into coupling yokes and other forms. Car axles are now made of steel, but when any of the old iron axles come in we usually roll them down to a size which will meet some particular requirement. Journal brasses are heated to a sufficiently high temperature to melt out the babbitt which is cast into pigs and used again. If the brasses are not too badly worn they are sent to an outside concern for re-babbitting; otherwise they are sold as scrap metal.

Waste which comes under the third classification and possesses only a junk or scrap value comprises a wide variety of material, inasmuch as it includes everything which does not come under the other two classifications. In all cases, however, this material is carefully sorted and given any treatment which may be necessary in order to enable it to be sold to the best advantage. For example, large quantities of worn-out dry cells which have been used for open-circuit signal work are sent in to us. These are broken up and the zinc shells melted, cast into pigs and sold. The *(Continued on page 46)*

Some of the Ways

Equalizers Will Reduce Unbalance and Noise

In Induction Motors Together with Details on Employment of Ring-Type Connections for This Purpose

CONSIDERABLE NOISE in an induction motor is usually a signal of trouble which should be remedied. If it is caused by unbalanced mechanical or magnetic conditions it can often be reduced, in the case of a parallel connected winding, by putting on equalizer connections. Such connections have by far the best effect when employed with a winding of the short-jumper type. There is a number of the facts concerning equalizer connections which are worthy of study. Details and information on working out these connections are given in this article.

By A. C. ROE

Repair Superintendent, Detroit Service Department, Westinghouse Electric & Manufacturing Company

WHEN any induction motor is in operation there is always present a certain amount of noise, caused by windage, magnetism, current and so on. The noise caused by unfavorable conditions of magnetism and current can, however, in some cases be reduced by using the proper type of connections and employing equalizers. The proper connections and equalizers are discussed in the following paragraphs of this article.

Magnetic noise is due, for the most part, to a pulsating field of high frequency which causes the laminations to vibrate. The amount of noise due to this cause depends upon the design of the machine. It may be lessened by using the correct proportion of rotor slots as compared with stator slots, by skewing the rotor slots, by using magnetic wedges and in other ways.

The current noise is due to unequal air gap, or any other mechanical, magnetic or electrical dissymmetry. Electrical symmetry can be secured by employing a well-balanced winding with equal coil groupings. This will tend to reduce noises caused by current. Often, however, there are other conditions present which cause an unbalance, even though the winding itself is perfectly balanced. The most common of these is an uneven air gap. Under such a condition the current noise can be reduced to a certain extent in parallel windings by the use of equalizer connections. In a series winding, of course, equalizer connections are not possible, and therefore cannot be employed to reduce noise. An equalizer connection may be applied to any parallel connected windings, but its ability to reduce noise depends upon the particular kind of winding. It will be greatest for a winding with short jumpers connected top-to-top. It will also have some corrective effects on a top-to-bottom type of connection (long jumper). On the right-and-left type of top-to-top connection an equalizer will be of practically no value. The effect of an equalizer on these different types of winding is discussed later, but first it may be well to discuss the effect of the unbalanced condition, and the reasons for the unbalance.

Suppose, for instance, we have an induction motor with uneven air gap due to worn bearings. When the rotor of the motor is out of center, approaching closer to one pole than the others, the air gap of the pole it approaches is decreased while the air gap of the pole directly opposite is increased. Increasing the air gap increases the reluctance, which means that with the same magnetizing current flowing, the total magnetic flux will be decreased. Likewise, at the pole where the air gap is decreased, the magnetic flux is increased. Where the magnetism has increased this will increase the pull on the rotor and tend to pull it still further out of line. As the magnetic flux on the opposite pole has been weakened the pull on the rotor on that side has also been weakened. Then, what is needed to correct this abnormal condition is some means of increasing the magnetic strength of the weak pole and decreasing the magnetism of the strong pole. Now this may be done automatically if proper provisions are made for a path for circulating corrective current. This is the object of the equalizer connection.

The counter-electromotive force and the resistance of a coil or group of coils limits the current flowing through this part of the winding. The current is forced through the group ordinarily by means of the voltage impressed upon the motor. Now in a parallel winding, if different counter-electromotive forces are set up in two parallel paths, a circulating current will flow around between these two paths. In order to make use of this principle for correction purposes, this circulating current must flow in the weak pole in the same direction as the main motor current, thus strengthening this weak pole. Conversely, the circulating current in the strong pole must oppose the main motor current, thus weakening the strong pole. The problem is to apply the different counter-electromotive forces in such a way that the circulating currents will flow in the correct direction through the different portions of the winding.

It may be well to explain here how this circulating current is in phase with the main current, and may thus be employed to strengthen it or reduce it. In any induction motor the magnetizing current lags 90 deg. behind the applied line voltage. This magnetizing current sets up a magnetic field that is in line with this current. In turn, this field induces the counter-electromotive force in the winding, this counter-electromotive force being directly opposite to, or 180 deg. behind, the applied line voltage. Then, when the counter-electromotive force of one leg of a parallel circuit becomes less than that of the other leg, a current will flow which lags 90 deg. behind the counter-electromotive force.

This current is in phase with the main magnetizing current, and is in a position to add to or subtract from this main current.

To explain this by a concrete example, suppose the diagrams shown in Fig. 1, represent a motor with worn bearings, which allows the rotor to drop downward. These diagrams show only one phase of a four-pole motor, the other phases being omitted in order to simplify the explanation. Suppose the rotor has dropped so that it is nearer to group 7 and further from group 1, while the distance from groups 4 and 10 remains practically the same as before. The connection shown in drawing *M* is for a 220-volt motor. If the motor windings were perfectly balanced and the rotor were in the center of the stator, the counter-electromotive force on each of the four groups would be about 55 volts. With the worn bearings, however, the counter-electromotive forces in the different groups are as shown in the small diagram *Ma* at the right of *M*. The voltages indicated in these small diagrams for all of the figures in these drawings are counter-electromotive forces. Then the voltage in group 1 is 50 volts; group 4, 55 volts; group 7, 60 volts, and group 10, 55 volts. If the motor draws 10 amp. the same current is flowing through each of the groups shown in this drawing because they are in series and, therefore, no corrective action can be obtained by equalizer connections.

Next, take the two-parallel connection as shown in *N*. This winding has top-to-bottom or long-jumper connections. As shown in the small diagram next to drawing *N*, there is no corrective action when no equalizer is used. Furthermore, when the equalizer is employed as shown in the right-hand drawing, there is some corrective action, but this is not very great. It may be explained that the figures in parentheses inside of this small diagram represent the counter-electromotive forces that would be generated if the groups were not connected in parallel. However, when they are connected in parallel a circulating current flows and the counter-electromotive forces change, as shown by the notations on the outside of the small diagram. We show in this diagram then that between groups 1 and 10 a circulating current of 0.5 amp. flows. This increases the current in group 1, which is desirable; but at the same time it reduces the current in group 10, which is not desired. Likewise, a circulating current in groups 7 and 4 reduces the current in group 7, which is desirable; but it increases the current in group 4, which is undesirable. Therefore, the corrective effect from this arrangement is not entirely satisfactory.

Next may be considered the right-and-left type of top-to-top connection, as shown in drawing *O*. This

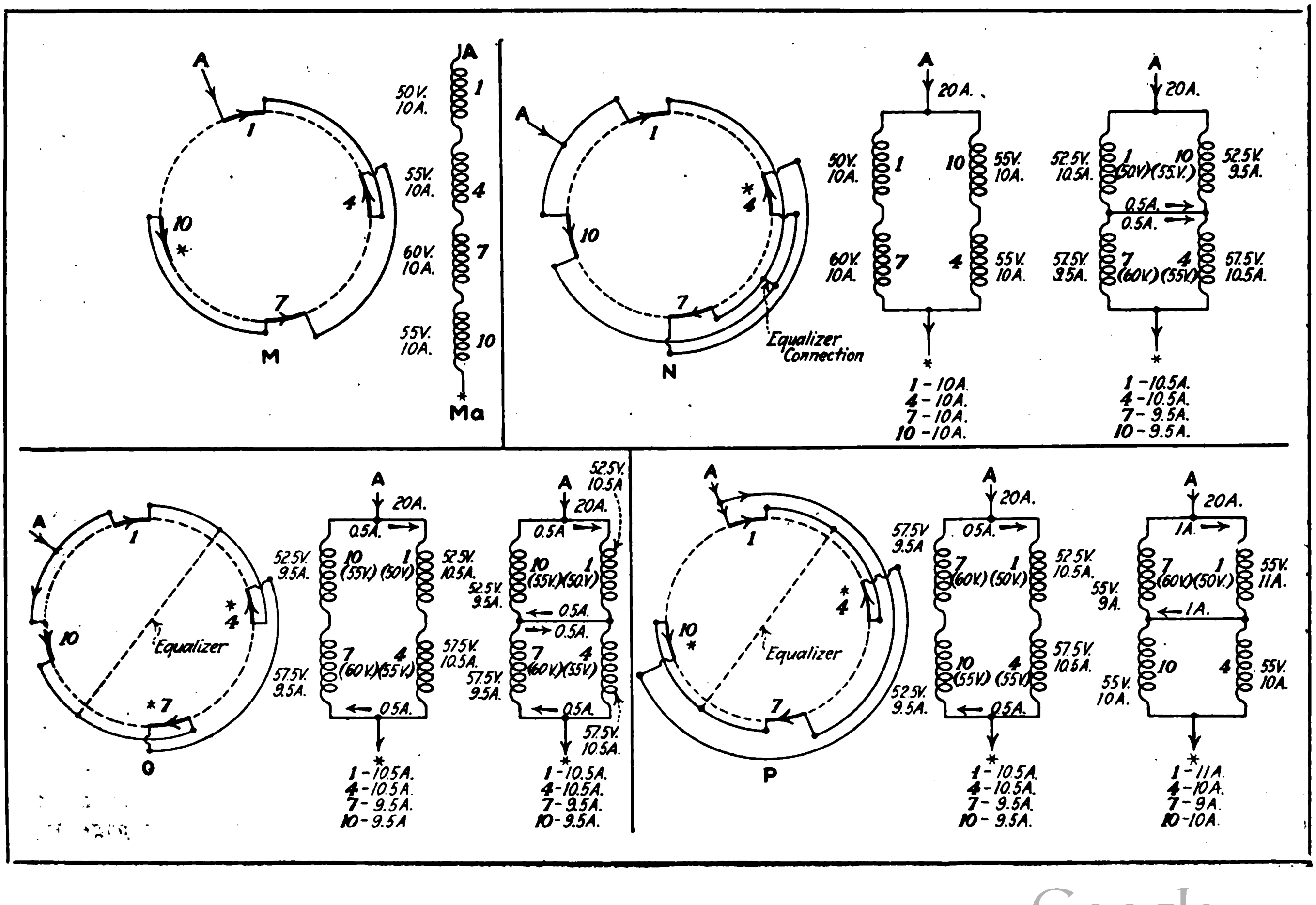


Fig. 1—Advantages of equalizer connections on various types of windings.

Each diagram, *M*, *N*, *O* and *P*, represents one phase of a four-pole motor. The small diagrams at the right of the circular diagrams show the connections schematically. It is assumed that the bearings of the motor have worn allowing the rotor to drop so that the air gap is decreased at group 7 and increased at group 1. Consequently, the counter-electromotive force in group 7 is increased from normal while that at group 1 is decreased. The counter emf. of each group is shown by the figures representing voltage, such as "55V." The letter "A" where it appears represents amperes. In drawings *N*, *O* and *P*, the counter emf. is shown inside the small drawings and enclosed in parentheses as "(50 V.)." This notation denotes the counter emf. which would be generated if there were no circulating currents flowing. But the voltage on each side of the parallel paths is equalized by circulating current. This voltage is represented by the figures outside the diagrams. The drawings at *M* show a series connection. No equalizer can be used on this. At *N* is a long-jumper, two-parallel connection. The equalizer has some corrective action. At *O* is a right-and-left, two-parallel connection. This winding has some corrective action without the equalizer but the equalizer does not increase it. At *P* is the best connection for corrective action. This is a short-jumper (top-to-top) connection. The equalizer gives the maximum corrective effect in this case.

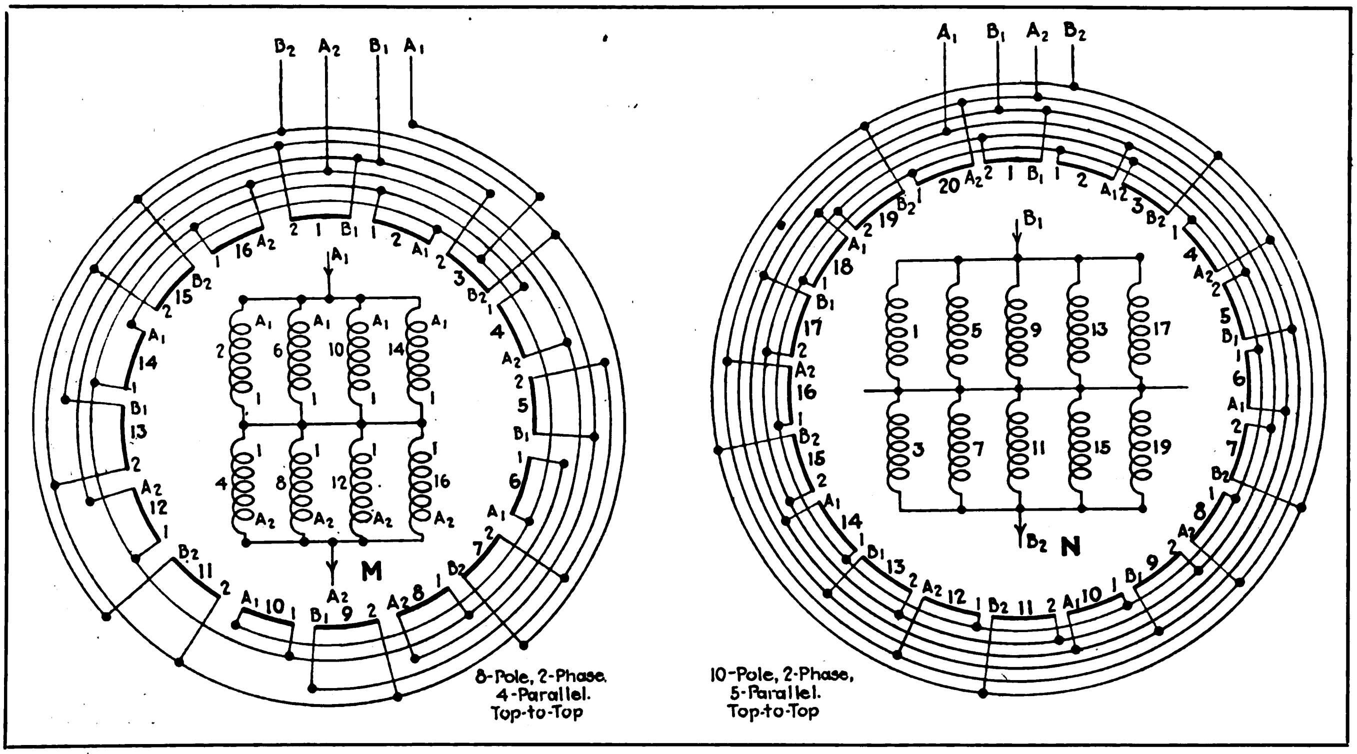


Fig. 2—Examples of long jumpers and ring connections.

At *M* the connections are by means of long jumpers to which are tapped the various groups. One long jumper, for instance, connects all the groups of one phase together. In place of this the ordinary connection would use four short jumpers located respectively between coils 2 and 4, 6 and 8, 10 and 12, and 14 and 16. This long jumper also acts as an equalizer. At *N* all connections are made to rings, of which there are six. Each of the two innermost rings in the diagram takes the place of five jumpers. In addition the rings act as equalizers.

likewise, is a two-parallel connection. When no equalizer is employed, as shown in the small figure directly at the right of drawing *O*, the original counter-electromotive force of groups 10 and 7 is greater than that of groups 1 and 4, and consequently a circulating current flows. This circulating current of 0.5 amp. adds to the main current in groups 1 and 4, and subtracts from the main current in groups 7 and 10. The result is the same as for the equalizer connection in drawing *N*. The current in group 1 is increased to 10.5 amp., which is desirable; but the current in group 4 is likewise increased to 10.5 amp. which is not desirable. The current in group 7 is decreased to 9.5 amp., which is desirable; but the current in group 10 is at the same time decreased to 9.5 amp., which is not desirable. Connecting an equalizer across, as shown in the right-hand small figure with drawing *O*, does not alter the positions. The circulating currents which would tend to flow through this equalizer connection are both equal to 0.5 amp., but they are flowing in opposite directions, and consequently neutralize each other. They have no effect on the currents flowing in the different groups.

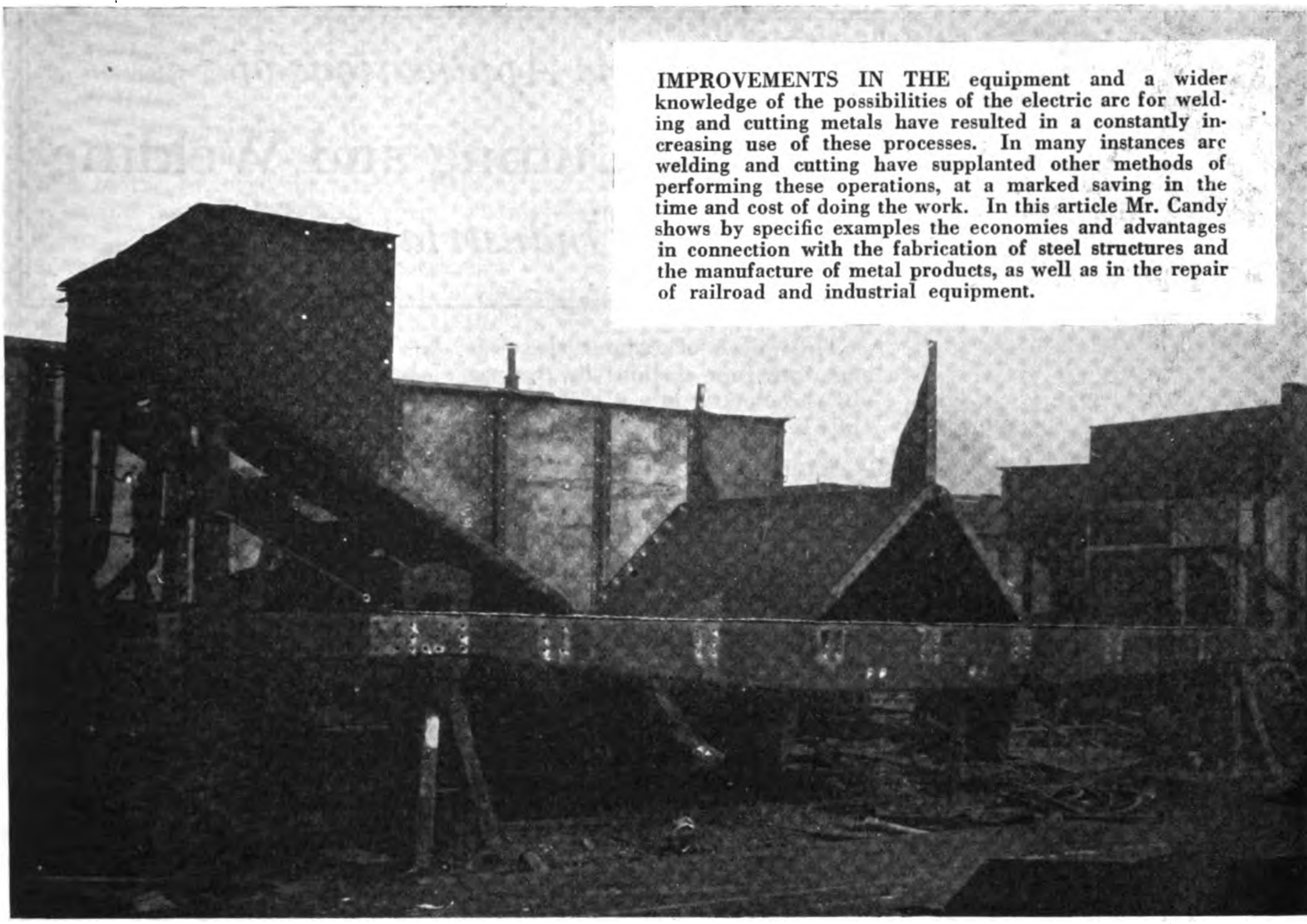
The next drawing shown in *P* of Fig. 1, illustrates a two-parallel top-to-top connection. In this connection the first series of groups ends on group 4, and the next series starts on group 7 which is the next group around the stator in the same direction. This is called connecting in parallel "on the half." Without any equalizer connection there is some corrective action as shown in the small figure directly at the right of *P*. This is the same as was obtained in the two previous cases, at *N* and *O*. However, by putting on an equalizer—as shown in the drawing at the extreme right—the maximum corrective effects are obtained. In this case the circulating current between groups 1 and 7 is 1 amp. This current adds to the main current in group 1, increasing it to 11 amp., which is desirable. Likewise, it subtracts from the main current in group 7, decreasing it to 9 amp., which also is to be desired. Furthermore, there is no circulating current between groups 4 and 10, which is the third desirable condition. Thus it is seen by comparing this type of connection with the others, that it is by far the best for securing corrective action automatically. This is the top-to-top or short-jumper type of connection.

The corrective effect of equalizer connections with a large number of parallel paths is very good. For instance, in a machine connected as in drawing *N* of Fig. 2, a complete group of coils could be cut out without any apparent effect on the operation of the motor. There might be some unbalance in the line current, but the motor would not overheat.

Where windings with unequal groups of coils are used, care should be taken that equalizers connect in parallel only such groups as have the same number of coils. As many equalizer connections as possible should be put on a winding. In a parallel winding in which three groups are in series, there should be two equalizer connections; in a parallel winding in which four groups are in series, there should be three equalizer connections; and so on.

Ring Type of Jumper Uses Lighter Conductor

The conductors used for these equalizer connections usually do not need to be as heavy as the conductors used for the regular jumpers, as they usually carry currents which are not very large. Often, however, the same wire which is used for a jumper connection is extended for the equalizer connection. This is true particularly in the case of ring-type connections or the very long type of jumpers such as those shown in Figs. 2 and 3. Details for the ordinary use (*Continued on page 45*)



IMPROVEMENTS IN THE equipment and a wider knowledge of the possibilities of the electric arc for welding and cutting metals have resulted in a constantly increasing use of these processes. In many instances arc welding and cutting have supplanted other methods of performing these operations, at a marked saving in the time and cost of doing the work. In this article Mr. Candy shows by specific examples the economies and advantages in connection with the fabrication of steel structures and the manufacture of metal products, as well as in the repair of railroad and industrial equipment.

The rivets in this steel freight car were cut by the electric arc at a cost of a little over one cent apiece. The cost of cutting these rivets by other methods will average between 2¼ and 2½ cents apiece.

Here Are Some Examples of

Arc Welding and Cutting Economies

That Have Been Made by Using These Processes for New and Repair Work

By A. M. CANDY
General Engineering Department, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

PROCESSES of arc welding and cutting were, until recent years, very much limited in application and found their widest use in railroad shops. Along with the improvement in welding equipment and more information regarding the application of the electric arc for cutting and welding a much broader field is, however, being opened up in various industries where this tool is coming into use in manufacturing operations. Before the management of any organization can determine the advisability of installing the electrical equipment needed for this work it is necessary not only to learn the cost of this equipment, but also the savings to be expected by replacing present methods and processes with the arc processes. The information given below will be of interest in this connection.

An example of the speeding-up of manufacturing processes by the use of arc welding is found at a certain boiler and tank works in West Virginia, which makes, among other classes of work, tanks 8½ ft. in diameter and 10 ft. high. The head and bottom are of 5/16-in. steel and the shell is of 3/16-in steel. The shell is composed of four plates assembled with rivets on 2-ft. centers. By the arc process one operator can now weld the shell plating and heads to the shell, using a single fillet along the lapped joints, in eleven hours. To rivet one of these tanks formerly required the labor of six men for eight hours.

Near Vallecita, California, a welding company has recently completed a 100-ft. tower constructed of spiral strips, which incloses a spiral stairway. In all there is a total of 7,200 welded joints. The engineer of this job estimates that the weight of a similar tower of the usual riveted construction would be about 13 tons, compared with an actual weight of a little over 3 tons for the steel used in the welded construction. The cost of the completely welded tower was $3,000 as against $12,000 which was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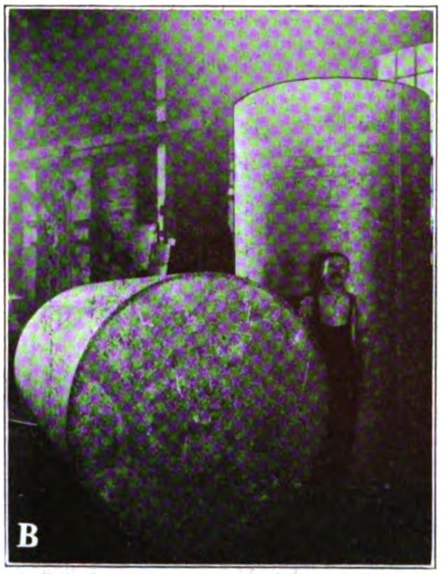
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Some Applications of
Electric Cutting and Welding
In Industrial Work

A—This piece of copper slag was cut into four sections by the use of the electric arc at a total cost of $15.40.

B—With the arc one operator can weld one of these tanks in eleven hours. It takes six men eight hours to rivet a tank.

C—This building, which is 200 ft. long and 75 ft. wide, was assembled by arc welding for less than it would have cost for the usual riveted construction employed in such work.

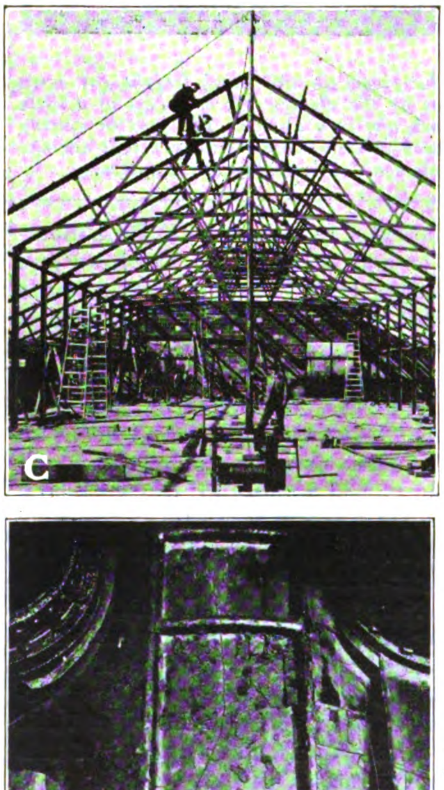
D—A broken mold for making automobile tires, before welding. These molds cost from $200 to $500 apiece.

E—The same mold after it was repaired by arc welding. The repairs cost less than $70, a small part of the cost of a new mold.

F—A 5-ft. crack in the cylinder of a 1500-hp., vertical blowing engine was repaired by arc welding for $737.20.

G—A V-shape groove was cut along the line of the crack and studs put in along the sides, preparatory to arc welding.

H—This shows the weld which was finished in 41 days and cost less than $750. A new cylinder would have cost $12,000 and could not have been obtained in less than nine months.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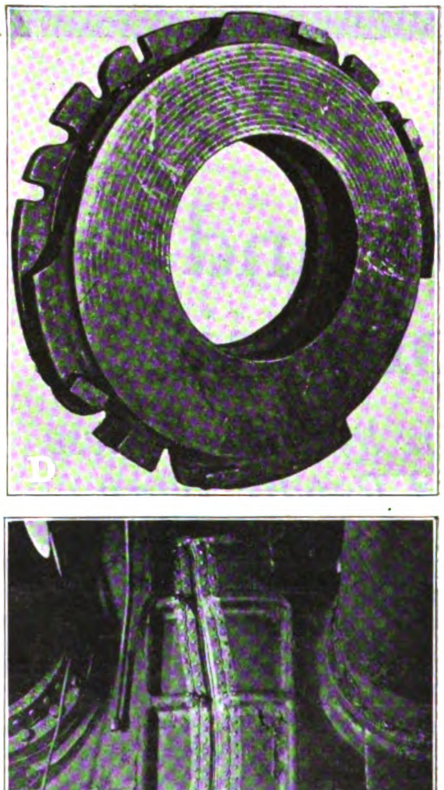
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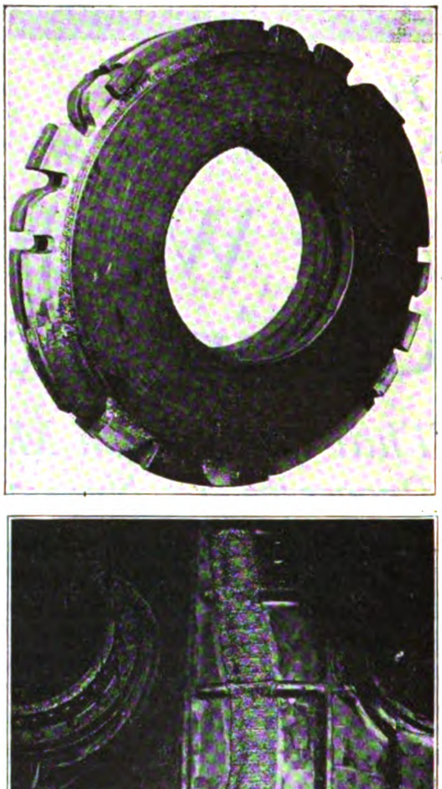

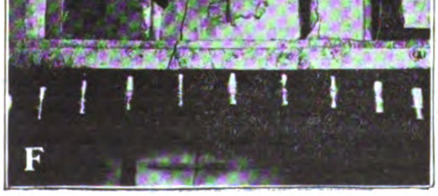
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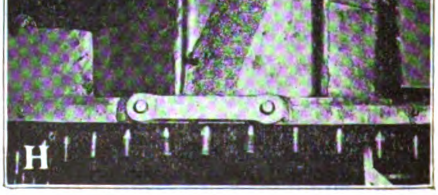
G


H

the lowest bid for a riveted structural steel tower.

Pipe lines using welded pipe of large diameter have also been laid; one job involved about 30,000 ft. of pipe. It was found that the pipe could be made from plate material rolled to the required diameter and length and then arc welded, thus producing it at a cost appreciably below the market price of the same size pipe. The sections of the pipe were welded together, end to end. This pipe line was used for dredging and showed a life several times as long as that of so-called standard dredge pipe.

In 1922 a 3,000,000 cu. ft. gas holder, 200 ft. in diameter and 100 ft. high above street level, was entirely constructed by arc welding by the Metropolitan Gas Company, of Melbourne, Australia. This holder comprises three telescopic lifts each 30 ft. high. When the job was completed only six pinhole leaks were found in the entire envelope, which weighs 600 tons and contains over 20 miles of lap-welded joints. The engineers of this company were so well satisfied with the job that a still larger holder was later constructed, involving four telescopic lifts each 30 ft.

As another instance of the possibilities of using electric welding in construction work, one of the accompanying illustrations shows a factory building, 200 ft. long by 70 ft. wide, the structural steel work of which was entirely assembled by arc welding at an appreciable saving over riveted construction.

In the field of repair work, the savings which are made by arc welding in place of other methods are sometimes very large. For example, one of the illustrations shows a broken locomotive cylinder, the cylinder ready for welding, and the completed job. The saving, compared with the cost of installing a new cylinder, is indicated by the following data:

Cost of welding cylinder (labor and material)	$ 125.00
Time out of service—5 days	100.00
Total	$ 225.00
Cost of new cylinder ready for locomotive	$1,000.00
Labor to replace it	150.00
Locomotive out of service 18 days	360.00
Total	$1,510.00
Credit for scrap value of cylinder	177.00
Total	$1,333.00
Cost of welding cylinder	225.00
Total saving	$1,108.00

Forge shops can save appreciable sums of money by repairing worn and chipped dies with the electric arc. Elsewhere there is shown a number of blanking dies for eye rods, bolt heads and other parts which have been reclaimed for service at a cost of from $5 to $10 apiece, whereas the cost of new dies will run from $35 to $50 each. The welded dies will develop from 50 per cent to 80 per cent of the life of a new die. In many cases however the ability to repair a die will eliminate the long delay required for obtaining a new die and therefore the saving in production time will be several times the cost of welding.

Another illustration shows an automobile tire mold before and after repair by the arc process. These molds cost from $200 to $500 apiece, depending upon the size and particular tread design which is cut in by hand. The cost of repairing this die by welding was as follows:

Preparation of casting	$14.40
Stud bolts	3.00
Steel to replace broken lugs	7.75
Welder's time	36.00
Welding wire	3.20
Electric power	5.00
Total	$69.35

Again, very large savings are being made in steel mills on many classes of equipment. In one instance the cylinder of a vertical blower engine, 80-in. bore, 60-in. stroke, 1,500 hp., which was cracked for a distance of 5 ft. on one side and 3½ ft. on the other, was repaired by welding. The total cost of repairing the cylinder, including reboring, was $737.20, compared with $12,000 for a new cylinder. The total time required for repairs was 327 hours, against 9 months required for delivery of a new cylinder, ready for installation.

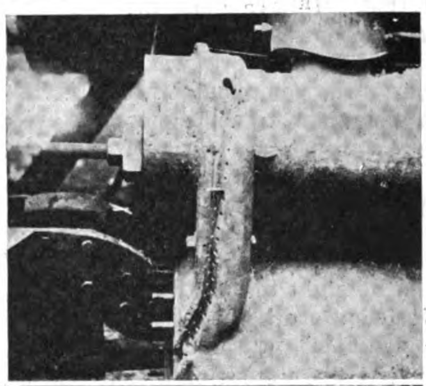
Again, mill spindles are being built up by the arc process in many plants. The larger spindles will cost several hundred dollars each. Rod mill spindles, costing $145 each, can be reclaimed for $25 to $30 apiece and the welded spindles usually give longer service than the original castings. It is not unusual to build up by welding spindles which are so badly worn that the cost of welding will be equal to the cost of a new spindle. The mill operators justify this, however, by the fact that the ability of the old spindle to withstand the service is known, whereas if a new spindle is installed it may fail prematurely.

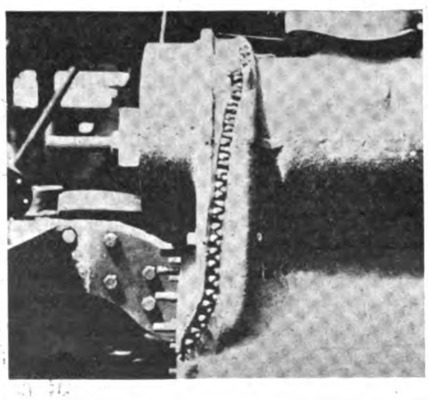
Steam railroad shops and electric railway shops have saved their companies thousands of dollars a year through the use of arc welding in the maintenance of rolling stock and equipment, as is shown by a few typical items given in an accompanying table.

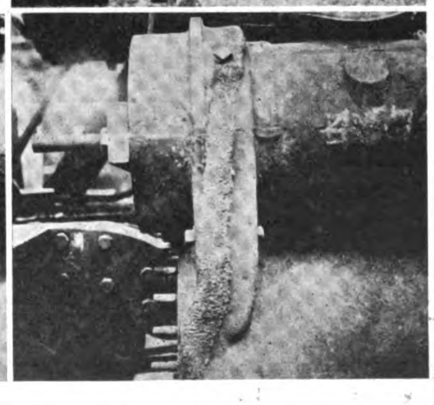
In the field of metal cutting, the arc process (*Continued on page 45*)

A saving of $1,108 was made by welding this locomotive cylinder instead of buying a new one.

This shows three steps in the process of welding a cracked locomotive cylinder by the electric arc. In the upper illustration a V-shape groove has been cut along the line of the crack and a number of small holes drilled and tapped to receive steel studs. The illustration at the left shows these studs in place and the cylinder made ready for welding. The finished weld is shown at the right. The studs are used to obtain a firmer union between the old metal and that deposited by welding and thus make a stronger weld.







INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT F. E GOODING A. J. WHITCOMB

Chicago, January, 1924

A Viewpoint on Passing the Buck

IF WE ALL had the same likes and dislikes combined with equal ability and were 100 per cent perfect, this would be a queer sort of a world. But in the plan of our Creator we are all different in some one, two or more ways and it's good that it is so. Too often we do not know this nor realize the way these differences can be made use of in life's work, its responsibilities and its rewards.

Perhaps the plainest indication of this weakness in our thinking is the attitude, shown so frequently, that failure to do the thing that seems perfectly evident is due to the fault of the other fellow. And when we fall short the suggestion that first comes to mind is that, "I have done my part but the other fellow has lain down on the job." Perhaps he did, but if that other fellow's work was in any way associated with your own, you, yourself, share his failure when you do not show a willingness to avoid the failure that you happen to be able to foresee.

In a word, we are fellow workers in a great job, each doing a part, and the completed work will be pleasing and satisfactory to the degree that helpful co-operation is reflected by all. In short, then, no man has the right to pass the buck or ride on the ability of his fellow worker. It's a simple case of push or pull! If you can't push or pull, then get out of the way, but do that in recognition of the one who is at your heels and from whom you can learn something so that you will known when and how to push or pull next time.

Importance of Maintenance in Production

IN a paper on "The Mechanical Engineering of Management in the Metal-Working Trades," at the recent annual meeting of the American Society of Mechanical Engineers, Robert T. Kent, a well-known consulting engineer, pointed out that before good management can become effective, it must be preceded by good mechanical engineering. This includes the engineering of the product as well as of the plant and equipment. All this work should be preliminary to time studies, schedules and other managerial functions. In discussing the engineering of the plant equipment—machinery, plant layout, and material-handling devices—Mr. Kent emphasized the importance of good maintenance as follows:

> The question of power bears an intimate relation to production and management. This subject means more than the power plant; it means power actually available at the cutting tools. This takes us back through the machine gearing, the belts and countershafts, lineshafts and motors to the generators, engines and boilers * * * *.
>
> Proper maintenance not only reveals the causes of lack of power, but frequently prevents these causes from occurring. It may, therefore, be proper to list a few of the causes of inadequate power that have come under the author's observation, and which were removed by the establishment of a proper routine of maintenance. These included lack of tension in belts; belts too light for the machinery; excessive lineshaft friction, remedied by the installation of roller bearings; machine gearing too light for the duty imposed on it; variations in voltage, due to improper power plant operation; the driving from the same lineshaft of machines requiring a relatively constant amount of power and of machines taking heavy drafts of power at more or less frequent intervals * * * *.
>
> Proper and adequate inspection and maintenance of the power-generating and transmission appliances will frequently postpone to the distant future the purchase of additional boilers, turbines, and generators, even in cases where these apparently are badly needed.
>
> There is another feature of maintenance which should not pass unnoticed. Nothing upsets production so much as equipment failures. The cost of a belt breaking during working hours far exceeds the cost of repairs to the belt. It includes the cost of idle equipment, of the wages of idle mechanics while repairs are being made and, perhaps most important of all, the loss of production and the disruption of the shop schedule. The same remarks apply to all other equipment failures. It is worthy of note that equipment failures seldom occur where regular maintenance is a part of the shop routine. Maintenance provides for preventive repairs, and insures against breakdowns. It may be set down almost as an axiom that shop maintenance is one of the fundamentals of good shop management.

Good production, backed by effective management should see that all the preliminary details of operation and its continuance are provided for before it can effectively produce through the managerial functions of planning, scheduling and controlling of work. A "key" machine down for repairs can throw a big monkey wrench into the gears driving production. This statement is as true in other lines of industry as in the metal-working trade.

Does Your Plant Layout Always Tell the Whole Truth

AN INSTALLATION Engineer for a large company recently called attention to several instances where failure of the engineering department to keep their layouts up to date, in works in which he was erecting equipment, was the cause of much delay and expense. In one case, a 24-in. water main, which was not shown on any plan and whose existence had been forgotten, was discovered after most of the required excavating had been done. Inasmuch as this pipe interfered with the new equipment and could not be moved the latter had to be redesigned to meet the new conditions.

In another instance excavation uncovered a large number of underground ducts containing cables and water and air lines. These, too, were not shown on the plant layout and had been forgotten. Again, redesign-

ing of the new installation was necessary, at a cost of several hundred dollars and nearly a month's delay in getting the equipment installed.

Instances of this sort are by no means as rare as might be supposed, but they represent a state of affairs for which there is little real excuse. It is true that in most works of any size extensions or changes are constantly being made, but that is all the more reason why these changes should be promptly and accurately recorded on the plant layout. Unless all power circuits, water, gas and other lines are clearly shown serious delays may be occasioned by the necessity of tracing out these arteries after failure has deprived the works of the vital service which they render.

An unreliable guide is worse than no guide at all, because it may not only give a false sense of security, but the information which it supplies may be misleading, and therefore dangerous.

How to Get the Job You Want

WHY WILL an outside firm pay you an increase in salary when they need you? Why won't your own firm pay you more to stay? One of them knows your present ability, the other merely knows you in a casual way. The outside firm, however, will not be fooled very long unless you produce the goods that it requires. Have you ever stopped to consider that your own firm might pay you more if you were delivering what the outside firm expects to get from you? Perhaps your own firm has you catalogued for one job and you are simply fulfilling the duties of that job and no more.

The shop foreman, to become an assistant superintendent, must know how to do the construction foreman's work, for how else can be hope to boss the construction foreman if he is unfamiliar with the work that the latter does? Likewise the shop foreman must know how to do a great deal of the superintendent's work, for he cannot be an assistant superintendent and expect the superintendent to do his work for him. In the final analysis the man who gets the increase in pay is the man who is in line for promotion and he is the one who not only does his work well, but can also do the work of his associates and has made his superior feel that he can do the boss's work, too, when the opportunity or emergency comes up.

How to convince a superior that such is the case calls for diplomacy in addition to ability. It can be done by displaying initiative on your own job, by doing your own job better than it was done before and by originating methods for doing it. These things show the boss that you can use your head to think as well as carry your hat.

Initiative, originality and resourcefulness can be developed in two ways—by reading and studying the books and methods of men who have done the things you are striving to do, and by contact with the men who are now doing the things that you want to do. But all of this study and contact is of no avail unless you are able to apply it to your own job for it is the application of what you know that lifts you up the ladder of success.

The requirements of success are the same in the plant across the street as in your own plant; so why not stay at home and get the job you want?

The New Year and Its Opportunities

ACCORDING to our method of measuring time, another twelve months of accomplishment is behind us and a new twelve months' period of opportunity is ahead. Hardly anyone who takes himself seriously is quite satisfied with what he has done and at this time of the year, when the deficiencies of 1923 go with the work of that period, it's natural and right that a fresh start should be made with all the confidence in the world that new things can be accomplished and placed to your credit in 1924 through proper and diligent application of the experience of honest effort already accumulated.

It is important that the viewpoint be right and the aim set high in this mental inventory of one's capabilities and in this connection we believe there is a whole lot of practical inspiration in those lines of Edgar A. Guest which go as follows:

The many will follow the beaten track
With guideposts on the way,
They live and have lived for ages back
With a chart for every day.
Someone has told them it's safe to go
On the road he has traveled o'er,
And all that they ever strive to know
Are the things that were known before.

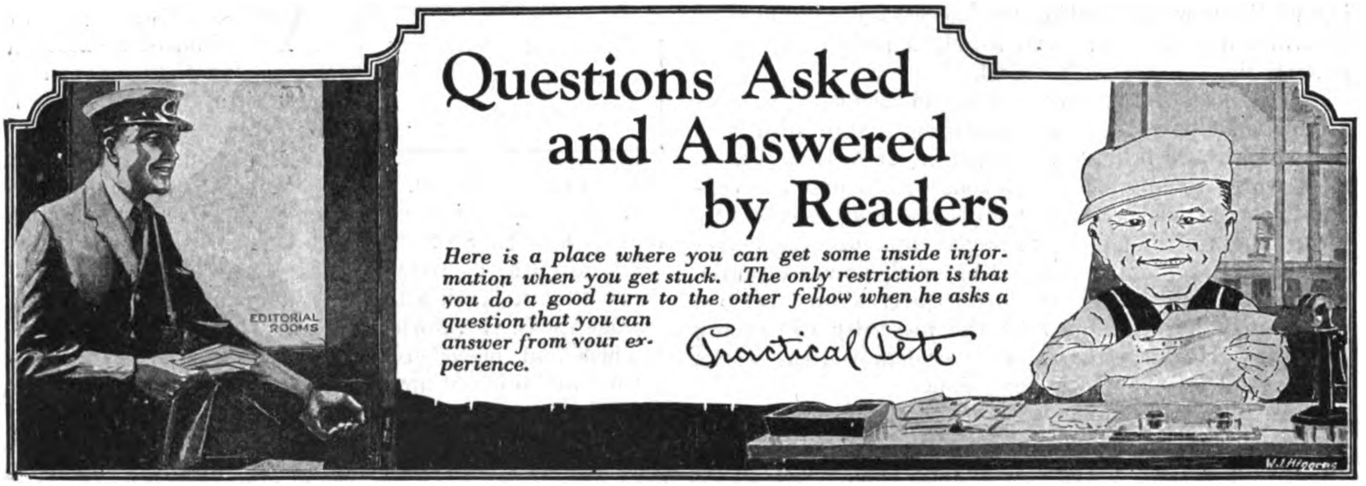
The things that haven't been done before
Are the tasks worth while today;
Are you one of the flock that follows, or
Are you one that shall lead the way?
Are you one of the timid souls that quail
At the jeers of a doubting crew,
Or dare you, whether you win or fail,
Strike out for a goal that's new?

Economists and business men have already expressed a confidence in the stability of business ahead. No threatening clouds are yet on the horizon. So with such a bright and cheerful beginning, we wish you, one and all, a wider vision and happiness and prosperity during 1924, in a fuller measure than you have ever enjoyed before.

Why Power Service Equipment Goes Wrong

THOSE who have been following the series of articles which have appeared in the INDUSTRIAL ENGINEER, covering power transmission equipment such as gears, pulleys, belts, silent chains, flexible couplings, clutches and cutoff couplings, have probably noticed that practically the same statements in regard to operating conditions have been made in connection with each item. Particular emphasis has been laid in each case on three primary essentials to good service —proper capacity for the operating conditions, correct installation, and the necessary attention after installation.

Where power transmission equipment has given trouble the cause can almost always be traced directly back to an utter disregard of one or more—frequently all three—of these primary considerations. Many pieces of equipment carry a black reputation in some plants when the real responsibility rests, not on the equipment, but upon the man whose job it is to get the most out of it under conditions that will make this possible. For carelessness and negligence there is no good excuse.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Putting Tires on Wheels of Bandsaws—Will someone be kind enough to tell me what is the best method of putting tires on the wheels of bandsaws? I shall appreciate this information very much.

Chicago, Ill. J. W. C.

* * * *

Winding Data for 15-hp. Motor—Will some reader of INDUSTRIAL ENGINEER please show me how to figure the winding for a motor in which the outside diameter of the stator lamination is 17 in., and the inside bore is 12½ in. The axial length of the core is 4½ in. The primary slots are 1¼ in. deep and the slot width is 7/16 inches. The tooth width is ¼ in., and there are seventy-two slots. I want this motor to have six poles and develop 15 hp.

Fayetteville, N. C. E. A. K.

* * * *

Transformer and Balancer Coil Connections—In our plant we are operating one 50-hp., one 30-hp., two 5-hp., and two 2½-hp. three-phase, 60-cycle, induction motors. The lighting load, single phase, amounts to about 10 kw. I wish some reader of INDUSTRIAL ENGINEER would give me a diagram showing how to connect three 5-kva. single-phase transformers and balancer coils to obtain 110-volt single-phase current for lighting from the 220-volt, three-phase line from our alternator. Will you also show me how to cut in on the power company's transformer in case our machine should get out of order, and how to cut out their meters and transformers both at the same time when our machine is ready to be put in service again.

Detroit, Mich. O. C. H.

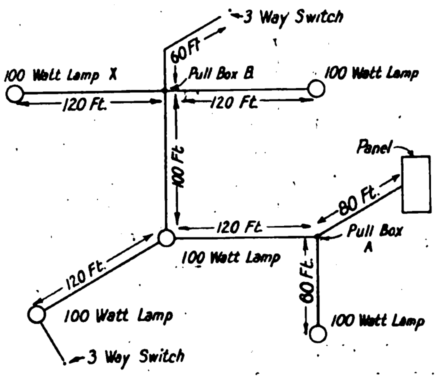
* * * *

Trouble with Large Generator—I wish some reader would answer the following questions: (1) We have a 150-kw. Westinghouse generator that will not compound when the load is applied. That is, when the load is on the voltage drops too low. Formerly this generator carried the load satisfactorily but during the past year we have been having trouble with it. What is the cause? (2) Should it be possible to ground together that is, connect the ground leads, of two generators, one of which supplies current to motors driving machine tools, while the other operates a motor which is connected to a pump? When we ground the generators together the breakers open and we have trouble, which disappears when the grounds are disconnected. What is the explanation of this? (3) Can two motor-generator sets be operated in parallel when their voltages are the same but they are not of the same size and do not run at the same speed? One set is rated at 200 kw. and runs at 1200 r. p. m., while the other set is rated at 150 kw. and runs at 900 r. p. m. (4) We have two generators, one of which is in a motor-generator set running at 900 r. p. m., while the other is steam-driven and operates at 225 r. p. m. The voltages of these generators are the same. Can they be operated in parallel?

Beaverdale, Pa. M. A. L.

* * * *

Why Do the Fuses on this Circuit Blow?—I recently wired a large concrete warehouse and should like to know why the 10-amp. fuses on the watchman's lighting circuit blow after the current has been on for a few hours. As shown in the diagram below, this circuit is controlled by two 3-way switches. No. 8 wire in 1-in. conduit is used throughout for this 110-volt a. c. circuit which contains five 100-watt lamps. From the panel to the first pull box, *A*, a circuit of No. 12 wire runs in the same conduit, and from the pull box, *B*, through the light *X*, another circuit of No. 12 wire is pulled through the same conduit. A grounded neutral at the transformer secondary supplies this building. Can some reader help me out?



Los Angeles, Calif. A. W. W.

Answers Received To Questions Asked

In his question in the December number of INDUSTRIAL ENGINEER, J. H. F. wants information on determining the charging rate of a storage battery. I will tell him of some methods I have used and which I think will help him solve his problem.

If the ampere-hour capacity of a storage battery is known, the charging rate can be found by dividing the capacity by 8. For instance, if the battery has a capacity of 80 amp-hr., then $80 \div 8 = 10$ amp. for the charging rate.

However, if the ampere-hour capacity is not known, another safe method is to charge at the rate of 1 amp. per positive plate per cell of the storage battery.

Another way of judging the charging rate is by observing the rise in temperature. The temperature of a battery which is being charged should not exceed 105 deg. F., or at the most 110 deg. F. If J. H. F. will put his battery on charge and watch the temperature for a time he may be able to determine very closely the proper charging rate.

J. H. BLAIR.

Moundsville, W. Va.

* * * *

Controlling Group of Polyphase Motors with One Compensator.—I should like to know if any reader of INDUSTRIAL ENGINEER has had experience with starting and stopping a group of polyphase motors, using only one compensator. This method is given in various textbooks, but details and specifications are lacking. We have a group of 440-volt, three-phase, 25-cycle motors ranging from 40 to 75 hp. which are started under no-load conditions, and very infrequently. If one common compensator is employed in conjunction with individual, double-throw, enclosed safety switches, can the latter be equipped with quick make-and-break and made fool proof by having to be

thrown first in the starting position? How can no-voltage and overload protection be obtained?
St. Louis, Mo. M. K.

* * * *

M. K. asks in the September issue about starting several motors from one compensator. When making an installation of this kind it is well to consider all of the factors involved as the cost of the complicated wiring may offset any anticipated advantages. I have installed several such systems successfully and the accompanying diagrams show the layout of two installations that gave good results as far as safety, convenience, and low maintenance cost were concerned.

The circuit in Fig. 1, *A*, is used to control seven closely grouped motors. The compensator and switches were all mounted on one panel. As the motors can be started consecutively by one man, the compensator needs to be only large enough to handle the largest motor of the group. Oil switches are used throughout as any type of airbreak switch would be hazardous for this service. Low

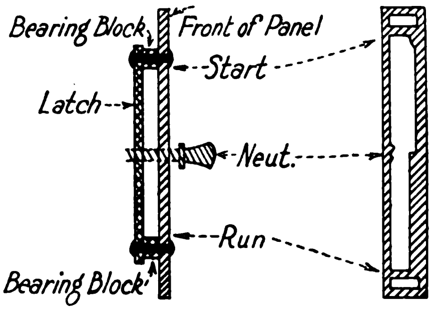


Fig. 2—Details of latch which was slipped over switch handles for safety in operation.

voltage protection is obtained from a circuit breaker in the mains.

The circuit in Fig. 1, *B*, is used to control a group of motors scattered over one entire floor and has never been out of service. The autotransformer is automatically controlled by a magnet switch operated from auxiliary contacts on the individual motor switches. Fool-proof starting was obtained by mounting

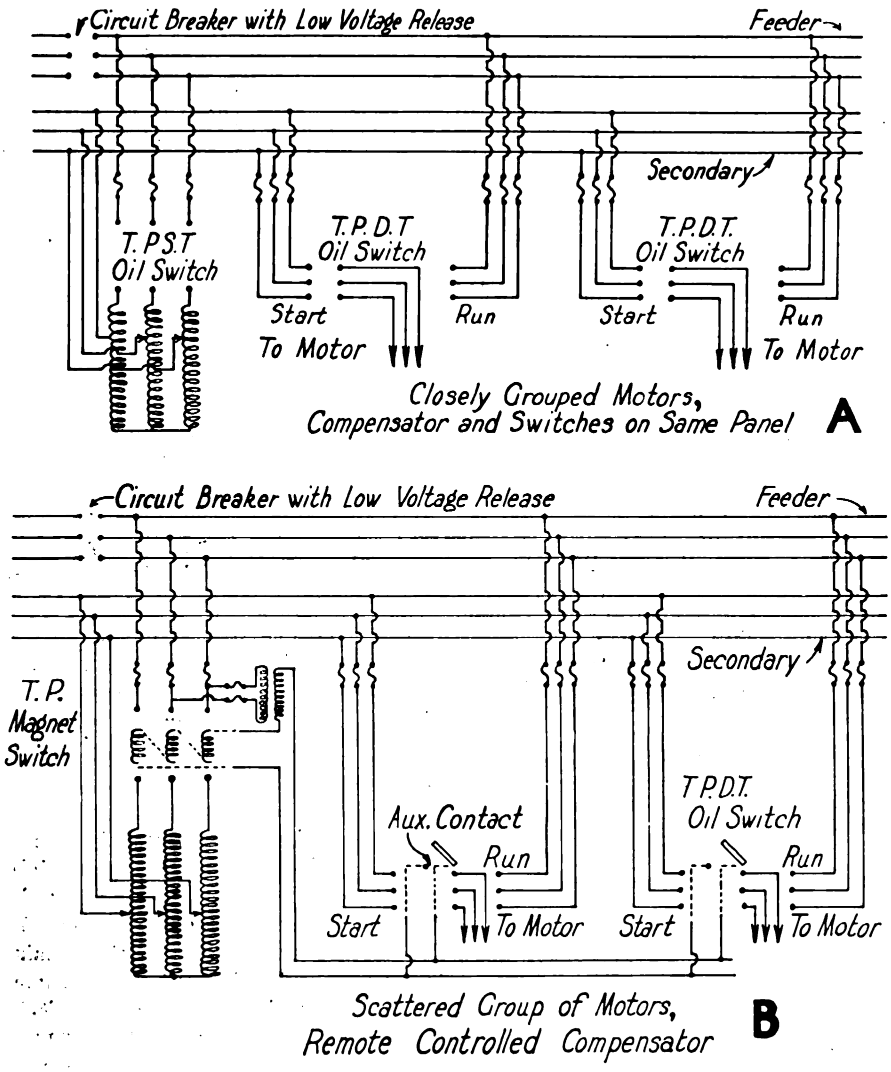


Fig. 1—Method of controlling a group of motors from one compensator.

a sliding latch, as shown in Fig. 2, on the switch handles. Panel-mounted switches were used and a latch was put on each one. The latch is slipped over the switch handle and mounted on the rear of the panel. It is operated by the projections at the start and stop positions. This is a rather flimsy and impractical-looking affair, but it has given satisfactory service. The compensator must be large enough to handle the number of motors liable to be started at one time, as the switches are scattered and can be operated by different men at the same time. I hope that the above will be of some value to M. K. D. F. O'DONNELL.
Chicago, Ill.

* * * *

In answer to the question asked by M. K. in the September issue, motors of anywhere near 40 to 75 hp. should, for various reasons, each have its own compensator with low-voltage release and overload relays. Any one motor which is overloaded should be able to trip the relays, and yet relays should not operate at full normal load. It would, therefore, be very hard to obtain the desired results with only one compensator for a number of motors. Again, if only one compensator were used it would have to have sufficient capacity to handle the combined motor load, which would not provide protection for any one motor which is overloaded if the others happen to be underloaded at the same time. A separate compensator, with all relays set about 25 per cent above the full load rating of each motor, will provide safety and good protection.
New Britain, Conn. H. S. RICH.

* * * *

Methods of Storing Spare Motors—I should like very much to have some of the readers of INDUSTRIAL ENGINEER describe the methods which they have devised for storing motors in such manner as to require the least possible floor space. We have over 200 spare motors ranging in size from ¼ hp. to 85 hp. A crane is available and we can pile as high as twenty feet, but floor space is limited and I must use it effectively.
Media, Pa. A. S. H.

A. S. H. asks in the October issue how motors can be stored so as to utilize floor space most effectively. Many motors of various sizes can not be stored as compactly as one would wish, but floor space can be saved by arranging them in pyramid fashion; that is, in separate pyramids.

I would suggest that he arrange four motors in a square; place short planks across them both ways and

place thereon three or four motors of a smaller size. Cover these with planks and place one or two small motors on top.

He can then arrange other pyramids in the same way, economizing on floor space. Thus, for every four motors on the floor there are four or five more above. This scheme permits a crane to take down any pyramid to reach any certain motor. Of course, it would pay to catalog them all and identify them by letters or numbers while in storage.

New Britain, Conn. H. S. RICH.

* * * *

Operating Two-Phase Induction Motor on Three-Phase Circuit—I should like to know if a two-phase induction type or squirrel cage motor can be run on a three-phase circuit, keeping the same speed and pulling the same load. I should like very much to have someone give me a diagram of such a hook-up and state if the two finishing ends of both phases or the start of one phase and the finish of another are hooked together. On what principles will the motor operate?

Chicago, Ill. J. H. B.

In answer to J. H. B., whose question appeared in the October issue, a two-phase induction motor can be reconnected to operate on a three-phase circuit. On a two-phase, 4-pole, 220-volt motor you have eight pole groups. Now in order to operate this motor on three phases, 220 volts, the coils will have to be reconnected so that you will have twelve pole groups. About 20 per cent of the coils will have to be cut out or left dead and the motor operated on the remaining 80 per cent of the coils. The speed will remain the same but the horsepower will be reduced about 15 per cent. Some of the coils must be cut out in order to keep the temperature of the motor as nearly normal as possible. Sometimes it is possible to reconnect a two-phase motor for three phases and use all of the coils, and then it will have practically the same horsepower. In emergencies a "T" or Scott connection may also be used.

Albany, Ga. B. BELCHER.

* * * *

In answer to J. H. B. in the October issue, I believe that you have the Scott or "T" connection in mind. One end of phase A is connected to the center of phase B, and the other end of phase A and both ends of B are the line leads, for three-phase operation.

An important thing about the "T" connection is that the stator must be connected long jumper or top-to-bottom in order to obtain good results.

If the short jumper connection is used and the air gap is not uniform, a higher voltage will be generated on the side on which the gap is smallest. This will unbalance each phase and cause the motor to overheat. With the long jumper a north pole cannot be affected without affecting a south pole; therefore, the winding will be self-balancing.

If the motor is 5-hp. or above, 14 per cent of the number of turns or coils in phase A must be cut out of circuit. If this is not done there would be a higher voltage in one phase which would cause the motor to give poor results through overheating, cutting down power factor and starting torque. With the same temperature rise as when the motor was operating two-phase, the horsepower output will be in the neighborhood of 87 per cent.

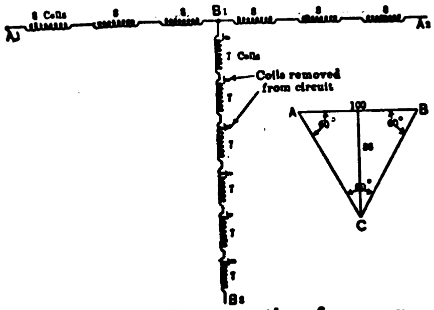


Diagram of T connection for operating two-phase motor on three-phase circuit.

If a two-phase motor is to be used permanently on three-phase it will pay to rewind it. For three-phase operation put in 1.73 times the total number of turns per phase with wire one size larger than is now used in the present winding and reconnect star with the same number of circuits as there were for two-phase operation. P. P. SCRIBAUTE.

San Francisco, Calif.

* * * *

Changing Small D. C. Motor to Operate on Alternating Current—I shall appreciate it very much if someone can tell me how I can rewind a small, 22-volt, direct-current, Hamilton-Beach vibrator motor to operate on 110 volts alternating current. The armature has 21 turns of No. 26 enameled wire and two coils per slot. The span is 1 to 6. The pitch of the leads is straight out. The two field coils are wound with 116 turns of No. 21 wire and the motor is connected in series.

Minneapolis, Minn. H. E. S.

In answer to the question by H. E. S. in the November issue on changing a 22-volt, direct-current Hamilton-Beach vibrator motor to operate on 110 volts alternating current, I would recommend that he use on the armature fifty turns of No. 35 enameled wire, two coils per slot, 1 to 6 span, and bring the leads straight out. Each field should be wound with 380 turns of No. 32 enameled wire.

I hope this information will enable H. E. S. to make the desired changes. E. H. WINKLER.

Chief Electrician.
Allen B. Wrisley Company,
Chicago, Ill.

* * * *

In answer to H. E. S., whose question appeared in the November issue of INDUSTRIAL ENGINEER, I would wind the armature with ninety-four turns of No. 33 B. & S. gage d.s.c. wire, making the connections to the commutator the same as with the old winding. Wind the fields with 522 turns, No. 28 B. & S. gage enameled wire. With this winding I believe his motor will give satisfactory results. B. BELCHER.

Albany, Ga.

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Finding Commutator Pitch of Armature Coil with Test Lamp—I should like to have one of our readers answer the following questions: (1) What is the best and quickest method of finding the commutator pitch of an armature coil with a test lamp? (2) What is the quickest method of stripping a partially-closed-slot armature?

Brooklyn, N. Y. H. C.

In the October issue, H. C. wants to know: (1) the quickest way to locate the throw of commutator leads with a test lamp. I do not know whether our way is the quickest, but I'll tell him how we do it. An experienced winder can tell at a glance whether the leads connect side by side or on the half. If the leads connect side by side, raise the top leads of about two coils and then test for the bottom leads. If the leads connect on the half, raise up the top leads of any two coils and then raise the top leads of two or three coils directly opposite, or half-way around the commutator. The bottom leads should be in the bars from which the top leads were raised. H. C. asked for the quickest way, but I want to say that in testing for the throw of commutator leads, as in everything else, the quickest way is not always the best.

(2) A quick way to strip a partially-closed-slot armature is to put it in a lathe, turn the leads off right behind the commutator and cut the coils off close to the core. Then take a small, round drift about the size of a slot and drive out with a hammer the portion of the coils left in the core. GEORGE RINGNESS.

Peoria, Ill.

Building Maintenance and Plant Safety

The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Blackboard for Indicating Location of Repairmen in Shop

SO THAT WE can locate a maintenance worker, who goes out into the shop on a job which is likely to take him 15 min. or more, we have him put his name and the department that he is headed for on a blackboard located in the shop. The foreman should see that this is promptly attended to and that the man rubs out his name and location when he returns. However, this will not be lived up to unless chalk and an old rag or waste tied to a string for an eraser are kept on hand.

Probably a better arrangement would be to have a blackboard with the names of the men printed on it permanently in white paint with a space at the right hand side for the man to write in the department in which he will be. H. S. RICH.
New Britain, Conn.

Portable Screens to Protect Nearby Workers from Welding Rays

WELDING operators are well protected from welding rays by helmets or goggles, but unless the entire job is shielded in some way, other workers are endangered in cases where welding operations are performed out in the shop. As these are often of a repair nature, it is essential to have a portable screen of some form. For this, we have found a very serviceable and handy screen can be made of light wooden frames covered with 12 oz. duck.

The framework is made of 1-in. by 3-in. pine; two pieces 6 ft. long are used for uprights, two 8-ft. pieces as horizontals and a piece 10 ft. long for a diagonal brace to hold the frame rigid. To make a totally-enclosed screen, four of these frames are used. These are placed end to end 2 in. apart and covered with one strip of 12-oz. duck, 6 ft. wide, extending the full length of the four frames. The 2-in. clearance between the sections allows them to be folded together and makes a stiff corner when erected. This makes a screen large enough to enclose a space 8 ft. square which would take care of most jobs. For larger jobs, the screen can be placed around the work in such a way as to shield practically all the nearby workers. When not in use it can be folded up and placed out of the way. ELZA HERRMANN.
Middleport, Ohio.

A New Department

MAINTENANCE in industrial works is as long and as broad as the area covered by the structures in which manufacturing operations are carried on. It is as complicated as the equipment and processes used and it calls for everyday vigilance to remedy the results of natural wear and tear in order to avoid the preventable losses and wastes that are ever present in all kinds of plants.

During the past two years requests have come to INDUSTRIAL ENGINEER from readers suggesting that attention be devoted to the odd jobs about the works that the maintenance department is called upon to do. This new department has, therefore, been established as a place for the discussion of these subjects by our readers. Details of any method, results or procedure will be welcome in connection with the maintenance associated with natural wear and tear or other depreciation of floors, walls, windows, roofs, ventilation, heating, sanitation, water supply, yards, tracks, roadways, drainage, fences, etc. In this connection repairs, cleaning, moving, rebuilding and extending operations will be taken up. In addition attention will be devoted to plant safety from the standpoints of accidents to workmen, their health, safety for machines and their operation and fire protection equipment, and fire-fighting methods.

The object of this department is to establish building maintenance procedure that is being followed with good results in different kinds of plants.

Breaking Up Large Sheave Pulley in Close Quarters With Dynamite

FREQUENTLY it is necessary to remove large pieces of machinery, foundations and so on from the inside of buildings where the use of ordinary methods would require the dismantling of a wall or interfere with the operation of the plant. Such a condition was encountered in the removal of a large rope sheave, 8 ft. in diameter with a 12⅝-in. face, which was almost totally enclosed with a partition within 14 in. of one side, another partition 40 in. from the other side, and a brick wall near one face, as shown in the accompanying sketch. This pulley, which weighed approximately 2,500 lb., was rusted tight on the 6-in. shaft of a water wheel driving a generator. At first two

men tried to demolish this sheave with sledge hammers, but could make no headway. It was then decided to use dynamite.

The sequence of operations, as reported in "The du Pont Magazine," was as follows: Holes ¾ in. in diameter were drilled through the spokes close to the hub; also, a row of ¾-in. holes was drilled crosswise along each side of the hub, as may be seen from the cross-section view in the accompanying sketch. Another hole nearly 6 in. deep was drilled into the center and on one side of the hub. This drilling job took two men about 6 hr.

With the wheel in position so that a spoke was vertical, a whole stick of ⅞-in. by 8-in. du Pont 40 per cent gelatine was exploded in the groove at the top center of the wheel directly over the spoke. This resulted in splitting the rim sideways and cracking it loose from the end of the spoke. This operation was repeated around the wheel, using whole and half sticks as pieces were loosened until the entire rim was broken into pieces which one man could easily handle. Care was used to break pieces from opposite sides in sequence so that the mechanical balance of the wheel was maintained sufficiently to permit turning it without too great an effort.

After the rim was removed, the holes in the spokes were then completely filled with powder; a cartridge was broken up and the loose powder rammed into the hole with a small stick. No wadding or tamping of any kind was used and the fused cap was inserted directly into a small hole punched in the powder. Only one hole was loaded and fired at a time. This small quantity of explosive was found ample to crack the spoke so that a light tap of a sledge sufficed to break it off completely. After removing the last of the spokes, weighing about 100 lb. each, two of the four holes on each side of the hub were similarly rammed full of powder and fired. This explosion cracked the hub but did not throw any small pieces around. The one deep hole in the center of the hub was then loaded with about one-third of a stick of explosive. The explosion split the hub through the center and dropped it in two pieces on the floor almost directly under the shaft, leaving the shaft clean and absolutely unmarred or cracked. This last charge was a little too heavy and the explosion drove some small pieces of iron through a partition. This emphasized the need of caution against overcharging. It is always better to fire a second shot if the first proves too small.

A total of about 30 sticks, or 8½ lb. of du Pont 40 per cent gelatin was used, with approximately 50 caps and 40 ft. of fuse. The total cost of explosive, fuse and caps for the job was less than $4. No capping was used. This caused the shots to be very noisy and as a matter of personal comfort ears were stopped. Windows were opened to lessen concussion and hasten the removal of smoke and gases from the shot to prevent "powder headache."

In doing such work it is always well to consult those who have had experience in the handling of dynamite, as there is always a danger of over-charging. H. E. BARNES.

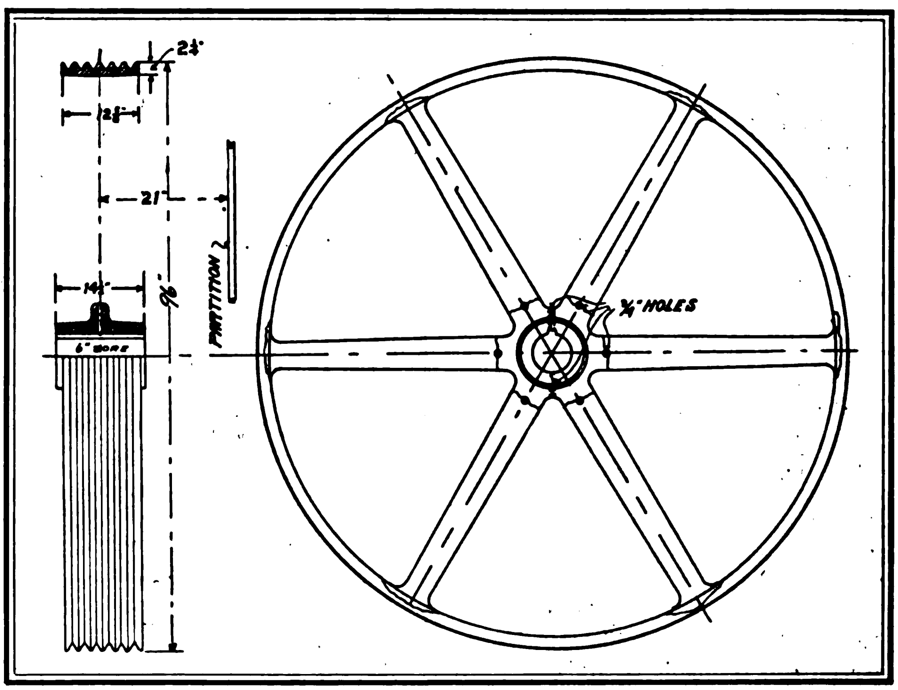
Excerpt from
The duPont Magazine.

Weekly Inspection of Factory Fire Fighting Equipment Report Card

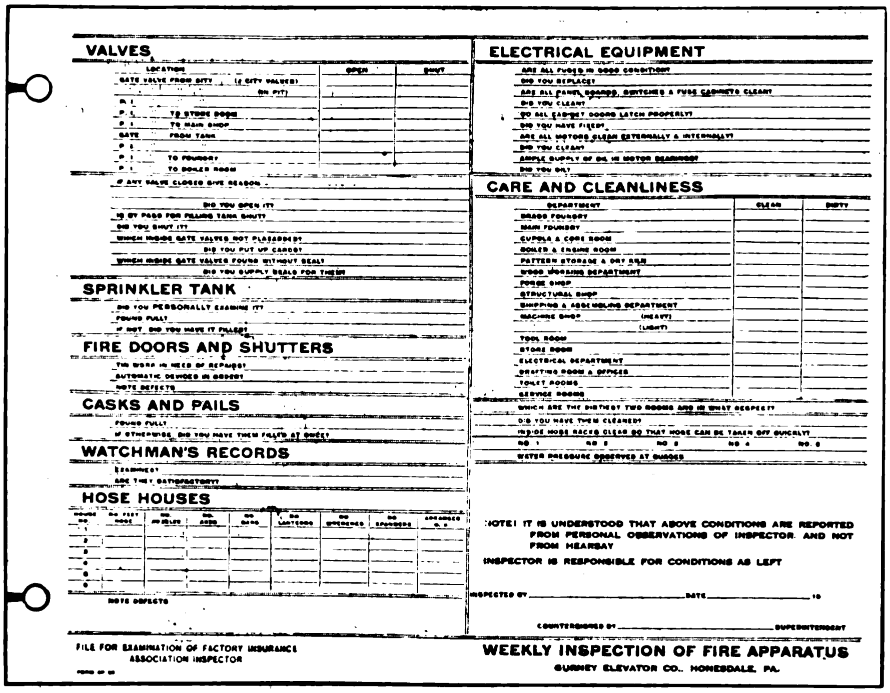
INSPECTION of fire protection apparatus and the detection of possible fire hazards are carried out in our plant after the following plan: Once a week, a responsible employee is detailed to make a careful check and record the condition of the plant as regards the items shown on the accompanying printed form. When finished this report is turned in to the superintendent, countersigned by him, and then filed in a looseleaf binder. The time of the inspection trip is usually Saturday morning or afternoon, although this time is occasionally changed.

The plant is equipped with a Rockwood full pipe sprinkler system, supplied from an overhead tank. This system reduces the amount of subsidiary apparatus necessary within the buildings, which are of slow-burning, mill-type construction, with brick walls. The additional fire-fighting equipment inside the factory consists of several lines of hose permanently attached to stand pipes, pails of sand in the forge shop, and Pyrene extinguishers placed near the larger pieces of electrical apparatus. These hand extinguishers have replaced the "casks" referred to on the inspection sheet. Refilling and replacing the extinguishers is a responsibility of the foreman of the department in which they are located.

Six small hose houses, which are stationed about the grounds of the plant, contain hose equipment for fighting fire originating on the outside of the buildings or in the storage yards, and thus supplement the work of the sprinkler system. These hose houses are located with a view towards making them effective for fighting fires originating on adjoining properties. The value of this idea as a matter of self-protection is worth while. A fire hydrant with a lock wrench attached is located in each hose house. In the inspection of these houses, the arrangement of



This sketch shows how an 8-ft. by 12⅝-in. rope sheave was broken up by blasting.



Once a week, a responsible employee makes a careful check of the conditions of the plant in regard to the items mentioned above.

the hose, couplings, and fittings is checked to see that they are in shape so that there will be no confusion in putting the equipment into use.

To insure the constant effectiveness of the sprinkler system, it is necessary that the state of the water valves be carefully observed. Therefore, this is the first matter taken care of on the inspection sheet. Next the heart of the system, the sprinkler tank, is looked after. The accessory protective devices and apparatus are then inspected as indicated.

Because dirt and disorder are regarded as the greatest of the common fire hazards, particular attention is given on the inspection trip to the conditions of the various plant departments. The last two divisions of the inspection sheet make it difficult for any unfavorable or dangerous conditions to go undetected for any length of time as they require the inspector to state definitely the dirtiest two rooms he has noted. This draws the attention of the superintendent to the sections of the plant which require attention, yet does not make the inspector feel any compunction with respect to his fellow-employees who are responsible for the places in question. Oily waste and rags are required to be deposited in galvanized-iron waste cans, with hinged covers, located at several points in the shop. Floor men regularly keep the floor clear of scrap and litter so that there should be no excuse for any department not being in first-class condition.

Semi-annually, the insurance company's inspector makes an inspection trip with the plant inspector. At this time, water pressures at the hose nozzles are measured, and the condition of the hose lines as regards water tightness is noted. The inspector then checks over the filed reports of the weekly inspections. The two inspections are thus tied together and serve as a check on each other. This increases the effectiveness of the plan in use, and takes full advantage of the insurance company's assistance in rendering conditions safer. J. M. WALSH.

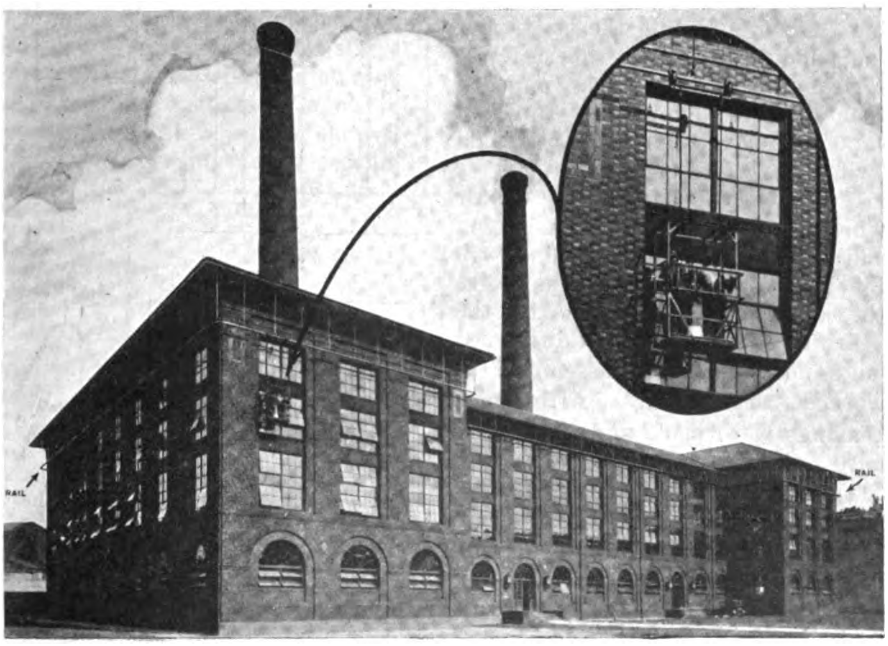
Gurney Elevator Company,
Honesdale, Pa.

Arrangement for Cleaning the Outside of Large Windows Safely

WITH the large increase in the use of glass windows in the modern industrial plant has come an additional problem of cleaning, painting, and repairing. Glass, unless it is kept clean, soon loses much of its lighting value. The windows are, however, often too large or too high, to be washed from the windowsill. Also, it is not always possible to use ladders, which at best are cumbersome and unsafe.

The accompanying illustration shows an application of a tramrail system (Cleveland Electric Tramrail Division of the Cleveland Crane and Engineering Co., Wickliffe, Ohio) which was installed on the pumping station of the Water Works department of the City of Cleveland to facilitate the cleaning of windows, some of which are 60 ft. above the ground. Before the installation of this system, the work was done by contract at a cost of $550. As the work was done from ladders, it was necessary to handle a ladder 66 ft. long to get at the upper windows.

Since the installation of this system, two employees do the washing of the windows in about a week's time. With this installation the men are in no danger from falling as would be the case with a ladder. In addition, the installation is available for replacing broken glass, painting, pointing brickwork and other miscellaneous outside duties.



With this tramrail and cage two men wash the windows on this entire building, in about a week.

SERVICE
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.

How to Use Rope in Pulling Stranded Cable

ONE WAY to pull a wire was shown in the June BULLETIN of the Pacific Power and Light Company. The story was told so interestingly that most of it is reproduced here.

"While we were busy making blocks to pull a section of wire an old workman ambled up and after looking on for a while said: 'Think maybe I can rig up something that'll work just as good as those blocks and without half the trouble.' Picking up a piece of rope the old man gave it a simple twist around the wire and said: 'There, that'll pull your old wire.' And it did.

"Here's the trick. Take a piece of rope and tape one end. Loosen the strands by twisting against the lay of the rope, place the rope on the wire, wrap it around four or five times, as shown in the accompanying sketch, loosening the strands as the rope is wrapped, and give a twist of the wrist. Simple, isn't it? Hard to explain and perhaps hard to work at the first or second attempt; but take a look at the sketch and remember that the rope is not weaved through the wire, but simply wrapped around it, as though the wire were a strand of the rope. Try it several times and once you get the hang of it you can't forget it."

New York City. E. H. H.

One end of the rope is taped and the strands are unloosened by twisting against the lay. The rope is then wrapped several times around the cable and twisted to tighten it.

Worn Bearings Cause of Starting Trouble in a Small Motor

THE EXPERIENCE of the writer in repairing a fractional-horsepower, single-phase motor shows how mechanical defects may often be the cause of trouble which is attributed to faults in the windings. A thorough examination of the motor seemed to indicate that only a new starting winding would be required. The bearings seemed slightly worn but did not appear to be worn enough to require replacing. After inserting the new starting winding the motor ran satisfactorily until the load was put on; then the motor would not run fast enough to throw out the centrifugal switch.

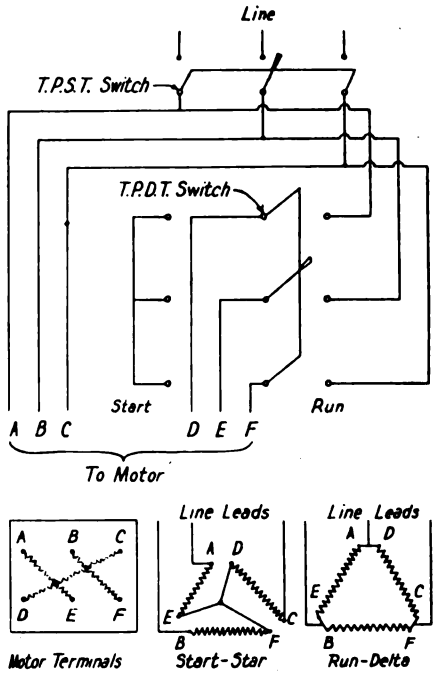
After worrying with the motor windings for several weeks during odd times, I finally decided to tin the bearings and see if they were the cause of the trouble. After the bearings were tinned and reamed out and the motor assembled it worked satisfactorily. After new bearings were made and inserted it gave no further trouble.

Tinning bearings of fractional-horsepower motors will frequently serve in an emergency, providing adequate lubrication is provided.

Albany, Ga. B. BELCHER.

Emergency Method of Starting Star-Delta Motor

A THREE-PHASE motor wound for use with a star-delta starter was recently sent to us for temporary installation on an emergency job. When the motor came it was found that the starter had not been included in the shipment. In order to avoid delay in putting the motor in service, and comply with the requirements of the power company, the method of starting shown in the



Throwing the three-pole, double-throw switch to the left gives the star connection for starting the motor. For the running position the switch is thrown to the right, which connects the motor windings in delta.

accompanying diagram was used with satisfactory results. As will be seen, a three-pole, single-throw knife switch was used as a line switch and a three-pole, double-throw switch served to change the connections of the motor winding from star to delta for starting and running, respectively. After throwing in the line switch the double-pole switch was placed in the starting position, giving a star connection for the motor windings and impressing about 58 per cent of the line voltage on them. As soon as the machine was up to speed, the switch was thrown to the right or "run" position with a quick motion, thus giving the delta connection, with full line voltage across each phase of the winding.

FREDERICK KRUG.

Comerio Falls, Bayamon,
Porto Rico.

Trouble from Grounded Rheostat of Motor-Generator Set

AN INTERESTING case of trouble came to the writer's attention recently on two synchronous motor-generator sets (150-kw., 250-volt) which were installed to supply power to a ground-return traction system using mine locomotives. One machine was tested and tried out under load and several days elapsed before the second machine was ready for a trial. The latter machine was run up to speed, the exciter rheostats for the synchronous motor were adjusted for the maximum power-factor correction and the voltage on the direct-current generator built up to 250 volts. The outside feeders were connected to the bus, one side of the feeders being connected to ground, the machine circuit breaker was closed and then the knife switch was closed. A slight flash occurred when this switch was closed and the voltmeter went to zero, while about 50 amp. showed on the ammeter only for a second. Such a circumstance indicated some derangement of the field circuit which was present only when the generator was connected to the feeder having a grounded negative lead.

With the machine switch open a test of the generator-field leads indicated a solid ground. The leads to the rheostat were disconnected and the generator and all leads tested clear but the ground remained on the rheostat terminals. The construction of the rheostat was such that its frame was insulated from the wiring, but its shaft was connected solidly to the arm of the moving contact. The shaft was insulated from its driving sprocket by a fiber disk between the sprocket rim and the hub. However, a close inspection of the rheostat mounting revealed an iron brace acting as a bearing for the shaft. After the first machine was tried out this brace had been added to give more support to the shaft because the spring in the shaft permitted sufficient slack in the operating chain to cause it to jump off the sprocket. All the equipment had been tested out for grounds and continuity of circuits before the first machine had been tried out. For this reason, the electrician installing the iron brace neglected, or thought unnecessary, a second testing for grounds; possibly he assumed that the addition of a piece of iron to the frame would not alter the circuit. This is a common mistake and one that should be watched by wiremen inasmuch as alterations or additions are often made after equipment is installed and every change or addition which is made should be subjected to close scrutiny and proper tests.

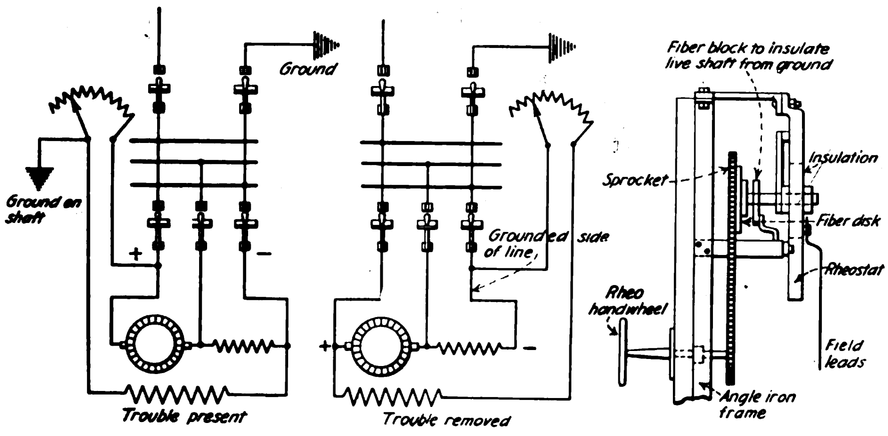
In this instance to clear the trouble it was necessary only to remove the support, saw about 2½ in. from the iron bar and bolt on a piece of ½-in. fiber drilled to fit the shaft of the rheostat and serve as an outboard bearing. To reduce the potential stress on the insulation of the rheostat and lessen the hazards in working on the rheostat, the negative or ground side of the line was connected to the rheostat and from the rheostat the line passed through the shunt fields and thence to the positive terminal of the generator.

J. ELMER HOUSLEY.

Electrical Engineer,
Aluminum Ore Company,
East St. Louis, Ill.

The rheostat was unintentionally grounded by addition of an extra iron bearing to support shaft.

As shown at the left the rheostat was originally connected in the ungrounded side of the field circuit. To remove the trouble a fiber bearing was substituted for the iron bearing, as shown at the right. As a further safeguard the rheostat was connected in the grounded line of the field circuit.



Lamp Indicator Prevents Blocking Up of Pipes in Sawmill

WHEN one motor in a group of inter-dependent machines stops it often causes trouble unless some means is used to indicate the breakdown. Such was the case in our wood mill and cabinet shop, where an exhaust system is used to collect the sawdust and shavings from the numerous machines. The sawdust and shavings are collected by sheet-metal pipes, one end of which leads to a large main pipe about 4 ft. in diameter and the other ends to hoods situated over each of the cutting tools, with some placed near the floor to collect the sweepings. A large fan in this main pipe, operated by an alternating-current motor, in turn conveys the refuse direct to the boiler house where it is burned. Through this system the machines and floors are kept exceptionally clean. In addition to this main fan or exhauster other fans, which are driven by 40-, 50-, and 75-hp., 550-volt, three-phase, alternating-current motors are each connected to a group of small pipes to individual machines at various points about the shop and act as boosters to gather the sawdust and shavings and discharge it into the main pipe.

The fan nearest to the boiler house, which may be called the main fan, is the most important, inasmuch as it conveys directly to the furnace all of the material collected by the other three fans. In case it stops for any reason, the other fans must likewise be stopped; otherwise,

the pipes soon become blocked, causing considerable inconvenience. The fans and motors are mounted overhead and when the main fan stops, as it does frequently owing to blown fuses or other causes, this fact would not be noticed because of the noise of the surrounding machinery until the pipes were effectively blocked. It requires considerable time and labor to clean these out and interferes to some extent with the operation of the wood-working machines.

Finally, in order to prevent this trouble I placed six 16-cp., 250-volt lamps across the motor leads to show when the current is on. These lamps are colored green and are located where they can be readily seen. When the lights go out we stop the other motors and prevent blocking pipes. LACHLAN A. MCEWAN.

Car Shops, Canadian National Railway,
Point St. Charles,
Montreal, Que., Canada.

One Method of Obtaining Clean Air for Air Compressors and Its Advantages

OUR solution of the problem of obtaining clean air for a 1,500 c.f.m. air compressor which was recently installed in our plant may be of interest to readers of INDUSTRIAL ENGINEER. The most logical place for the air intake was near a centrifugal-type dust collector located on the exhaust from sandblasting machines. Unfortunately this dust collector occasionally emitted a fine dust consisting chiefly of emery, iron dust and sand which would cause serious wearing of the valves, pistons and cylinders of the compressor, if it entered the air intake.

The intake pipe could, of course, be lengthened, and by making several bends, reach a place where the air was cleaner; or the intake could be near the dust collector with some sort of air filtering device installed to remove the fine dust from the air. This latter arrangement, provided a satisfactory filter was obtained, seemed best suited to the conditions, as it was not only cheaper but also would offer less resistance to the air entering the compressor.

After considering several ways to obtain clean, filtered air, it was decided to use the Midwest air filter. This filter, which is made in standard units, has a filtering medium consisting of hollow metal cylinders coated with an oily substance, "Viscosine," to which foreign particles in the air will adhere. Our needs required four of these units which were mounted on one face of a large wooden box, which is placed against the side of our power house about four feet above the ground level, as shown in the accompanying illustration. Two ordinary house window blinds or louvres, which can be swung aside when it is desired to inspect or clean the filter, protect it from snow, ice and rain. The pipe line leading downward from the chamber back of the filter conducts the clean air to the compressor. We also arranged to have two other air compressors obtain clean air by having a second intake pipe lead from the air chamber behind the filter. These older compressors have capacities of 700 and 350 c.f.m. respectively and are run mostly at night when the new machine is not in operation.

As a result the fine sand, emery and iron dust, which we especially desired to keep out of the compressor, were easily caught. Later, however, the sandblasting system was improved so that practically none of this dust was exhausted. Even then, when conditions were supposed to be quite clean about the plant, it was surprising to see the large amount of dirt and dust still collected by the filter and kept out of the compressor.

The air filter requires but little attention. Every Saturday a dirty unit is removed and replaced with a spare clean cell, so that each of the four filter units remains in service for four weeks. This is more frequent cleaning than is really necessary, as the filter could absorb much more dirt, but this arrangement makes an easy and definite schedule to work upon. The entire operation of changing cells and washing the dirty cell in hot water or blowing out the dirt with low-pressure steam does not take more than 10 or 15 min. of one man's time each week. Afterwards the cell is dipped in a bath of Viscosine, as shown in the smaller of the two illustrations, and put aside to serve as a replacement cell on the next Saturday.

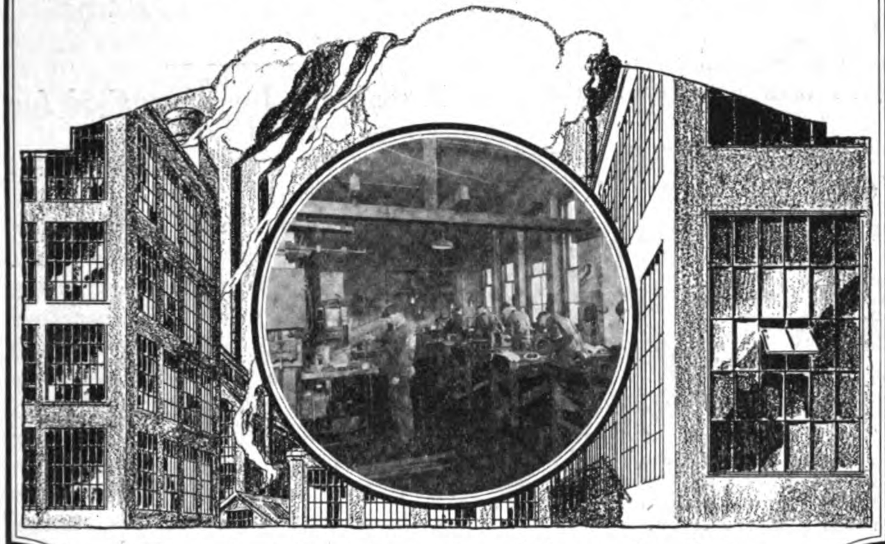
From observations of this installation it is probable that many air compressors in industrial plants work under conditions which, if improved, would make the life of the compressor much longer. As an example, this plant requires about 750 c.f.m. of air and the new compressor is run at about half capacity. The two older compressors with a total rated capacity of 1,050 c.f.m. are now unable to deliver even 750 c.f.m. without running at overspeed. The reason for this is that during the years these compressors were in service dirt and dust, which had entered the cylinders with the air, had caused a continual grinding action. This gradually allowed more and more air to escape by the pistons so that the capacities of the compressors were reduced considerably below their rating.

Another point noticed since using filters is the small amount of lubricating oil required. A new mechanical lubricator has been installed which helps save oil, but most of this saving is undoubtedly due to the clean air, because if dirt enters the compressor, oil must be used to flush it away. CLIFFORD H. LEIGHTON.

Chief Engineer,
Saco-Lowell Shops,
Newton, Mass.

Intake air for a compressor is filtered through the four special filter units at the left. These units are removed and cleaned as shown at the right.

In the Repair Shop

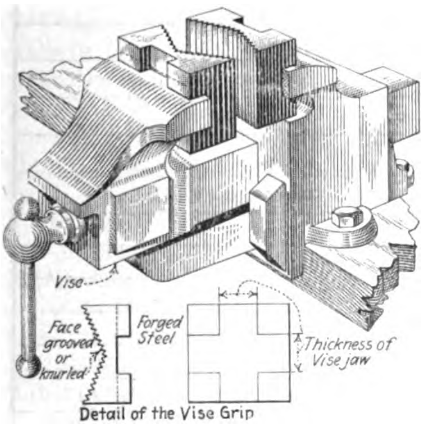


This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Construction of Simple Grips to Make Vise Hold Cylindrical Parts

CYLINDRICAL parts are frequently held in the vise with a file or wrapping of emery cloth to grip them, or sometimes two wooden blocks are placed in the vise and clamped down to imbed the parts in the wood. Two grips, made as shown in the accompanying sketch, will give satisfactory service and eventually pay for themselves in the saving of time and expediting of the work. These grips are demountable and are placed over the vise jaws in either position, so as to hold parts vertically or horizontally.

As shown, the grips are identical and should be made from forged steel, the grip surface being cut with angle or inclined faces, with the backs slotted in two directions to correspond to the thickness of the vise jaw. It is advantageous to cut shallow grooves in the faces or knurl them if considerable heavy work on round parts is to be done. It is also advisable to harden the grips, insuring a lasting durability for the grooved faces.



With these grips round parts can be firmly held in either the horizontal or vertical position, as most convenient, in the bench vise.

The usefulness of these grips lies in the fact that the work can be held in the position which is most convenient for the workman. Also they are easy to make. G. A. LUERS.
Washington, D. C.

Easy Method of Putting New Bars in Rotor of Induction Motor

A REPAIR-SHOP method of making a squirrel-cage winding for an induction motor was used in our shop some months ago. We had several induction motors that had been burned up in a fire. Most of these motors were of the wound-rotor type, with internal resistance and it was desired to use some of them instead of buying new ones. The stators were, accordingly entirely rewound in the ordinary way. In repairing the rotors, however, a suitable method had to be worked out.

After a thorough cleaning, copper bars from an old wound rotor were first well tinned, cut to a length about 3 in. longer than the width of the laminations on the rotor and slipped through the slots. The bars about half-filled the slots. The overhanging ends were then bent so as to bring the bars together, to form as nearly as possible a continuous ring. Some tinned copper wire was then wrapped around the exposed ends of the bars to hold them securely in place.

The rotor was then placed upright and enclosed by a bent plate of sheet iron, and all crevices were plugged up with clay. Next the whole space left in the slots was filled up with babbitt. At the same time a space was left at both ends of the laminations so as to form two rings of metal completely embedding the bent ends of the bars. After cooling, the rotors were put in a lathe and the excess metal turned off, making a neat job.

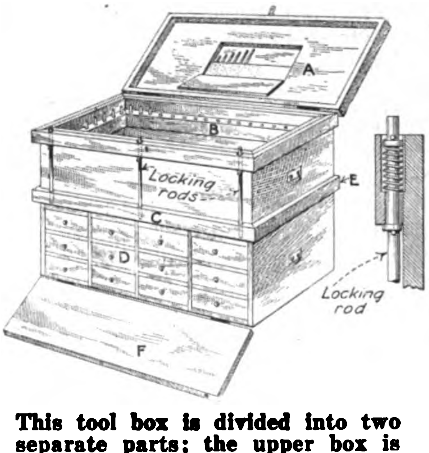
Zinc was first used instead of babbitt, but did not give good results, as it does not flow easily enough.

The repaired motors, which are mostly of 10-hp. and 15-hp. rating, are working satisfactorily, the only drawback being that they have a rather low starting torque.

ALBERT RUDIN.
Superintendent Electrical Dept.,
Abangares Gold Fields,
Costa Rica.

How to Make a Convenient Tool Box That Keeps All Tools Accessible

EVERYONE who uses tools has at some time considered the problem of making a tool chest that would hold his tools in a compact space, yet keep them so that they would be accessible. The main advantage of the chest described below is its accessibility—there is a place for everything and everything



This tool box is divided into two separate parts; the upper box is used for large tools. A large drawer between the two boxes is subdivided into small sections to hold miscellaneous bolts and screws. The lower box is fitted with drawers for small tools.

is in its place. The top section has an open space, the full width and length of the box, which is for large tools. The bottom section has drawers for the small tools.

The chest is made up of two boxes, independent of each other and separated at *E*, as shown in the sketch. This facilitates moving the chest around. The cover of the top box is cut under the panel as shown, making a space which is used for storing drills, and is fitted with a cover. Strips, *B*, are nailed around one side and the two ends of the box. Holes are drilled in these strips for automatic screw driver tips, reamers, punches and the like. The hand saw is held on the other side. The box has a false bottom below which is a drawer, *C*, the full size of the box. This drawer is divided into small compartments which hold stove bolts, screws, washers, and so on.

In the bottom box there are twelve drawers, used for pliers, screw drivers and other small tools.

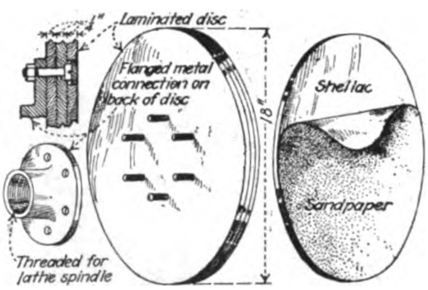
The two boxes are fastened together by bolts which pass through the floor of the upper box below drawer *C* and through the top of the bottom box. When the top cover *A* is closed, the locking rods pass through drawer *C* and engage in the holes at edge of cover *F*. A padlock on hasp of cover *A* will lock entire box. J. H. SAUVE.

Temiskaming, Que., Can.

How to Make Surfacing Wheel for Use in Lathe

FINISHING the surfaces of parts made of wood or other material by sanding with a hand block and sandpaper is a slow, laborious process which is much less effective than the use of a sanding disk. As will be seen from the accompanying illustration, the sanding or surfacing disk is a revolving disk faced with sandpaper or emery paper of the desired grade and mounted on the head spindle of a turning lathe. The disk is revolved at a high rate of speed and the material to be surfaced is brought into contact with the face of the disk. The work may be placed on the tool rest while it is being finished. The surfacing operation will only require a small fraction of the time necessary to do the same work by hand. If wooden parts are to be surfaced, the wood does not require any previous finishing with a plane.

The surfacing wheel is easily made and the materials are usually available in the shop. The wheel disk should preferably be made from a laminated board formed by gluing three layers of $\frac{1}{4}$-in. basswood or close-grained white pine solidly together. Care should be taken to see that the grain of the layers does not run in the same



The disk is made of three layers of wood glued together and firmly fastened to a threaded flange which screws onto the headstock spindle of the lathe.

direction. This laminated piece should be turned down into a disk about 18 in. in diameter and fastened to a threaded metal flange which screws onto the headstock spindle of the lathe. The disk should be fastened to the threaded flange with bolts. The heads of the bolts should be sunk into the disk and the holes filled in with wooden plugs cut off flush with the surface. This disk will be driven at the highest obtainable speed, and for that reason it should be fastened to the flange in a dependable manner. Sandpaper or emery paper of any desired coarseness may be fastened to the face of the wheel with shellac. After the abrasive paper has been put on the disk, it should be held firmly in place and the shellac allowed to dry for a short time before the disk is used. G. A. LUERS.

Washington, D. C.

Record and Inventory Card for Electrical Equipment

THE MOTOR inventory and maintenance card shown below has been drawn up primarily for the shop electrician's use. As will be noted, complete manufacturers' data as well as the operating characteristics of the apparatus, can be filled in, so that whenever it is necessary to order a bearing or to communicate with the manufacturer relative to the equipment in question, the necessary information is right at hand. This saves considable time and trouble and does away with the usual necessity of climbing ladders to read name-plates or, at times, of shutting off the power and temporarily interfering with production.

The lower half of the card, as well as the reverse side, is ruled off to show at what times the motor has been cleaned or repaired. In this way a complete record of all work done on the motor in question is kept on file. This card can also be used for inventory purposes.

The same card can be used for generators, motor starters, compensators, oil switches, and so on, crossing off the word "Motor" and substituting the name of the other substituting the name of whatever other electrical apparatus is to be cataloged. D. FLEIGELMAN.

American Chain Co.,
Bridgeport, Conn.

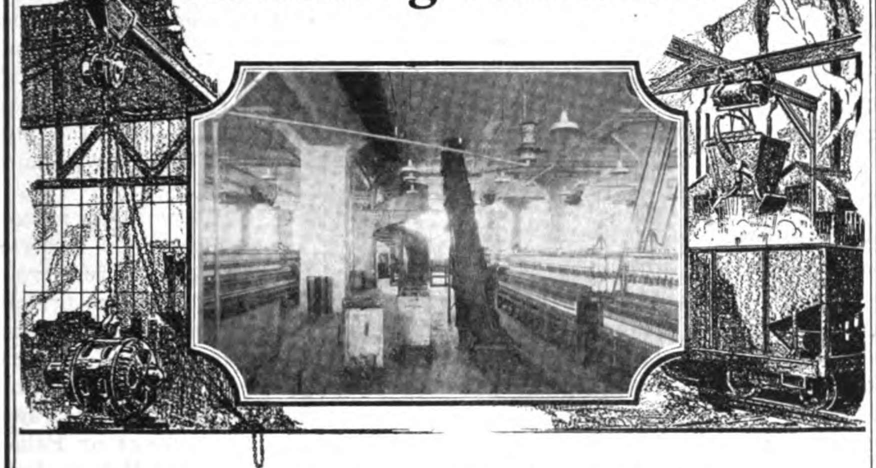
With a card like this a complete record of any piece of equipment is always available.

TAG NO.	H. P.	R. P. M.
MFTRS. NAME		MFTRS. NO.
TYPE	FORM	AMPS.
AC/DC VOLTS	PHASE	CYCLES
BEARING NUMBERS:		
FRONT	CENTRE	PULLEY

CLEANED	REPAIRED	REMARKS

909-S-500-7-23-Acco MOTOR EQUIPMENT RECORD

Handling Materials



Better ways to transport and handle raw and finished parts in and around the works and the savings associated therewith will be discussed in this section

How Material-Handling Equipment Pays for Itself When Storing Stock in a Small Plant

THE VALUE of material-handling equipment, even in a comparatively small shop where the equipment is idle much of the time, is well shown by the experience of the Wirth Sales Book Company, Chicago, Ill. Here paper is received in rolls in carload lots. The former practice with the small shop was to practically stop production, as it required twelve men to unload a car. The paper was rolled on edge from the car door to the pile and then tiered by passing up from one pair of men to the next, and so on up to the top of the pile. In this way the height of the pile was limited, and it was hard work. Also, there was considerable damage to the paper through the men standing on the rolls while piling. The bruised and torn edges caused considerable trouble in the passage of the paper through the printing presses.

Since a portable tiering machine, as shown in the accompanying illustration (Standard Conveyor Company, St. Paul, Minn.), was installed, this work has been done by a man or two in about one-fifth of the time formerly required. In addition, the paper is piled high enough to get a carload in one-third of the space formerly required. One of the important points to be considered is that now the receipt of a car of paper does not interfere with production, while the elimination of the damaged paper alone would more than pay for the machine within a year.

In addition, the tiering machine is as convenient for removing the paper from the pile and lowering it to the floor. With it, one man can do the operation easily and safely and without damaging the paper. While this is a hand-operated machine, as pictured here, an electric motor may be attached to raise and lower the platform. Also, the upright is hinged, so that by loosening a few bolts the top can be tipped over for the machine to go through doorways or under low beams.

Piling paper with a tiering machine in a small printing concern.
Formerly twelve men had to stop work on production and help unload a carload of paper when received. Now one or two men do the job in one-fifth the time, with less labor, and in addition pile the material in one-third the former space. Also, as the men do not have to stand on the rolls, the saving in damaged paper alone more than pays for the machine each year.

How a Change in Operation Resulted in More Work from Tractors and Trailers

FREQUENTLY it is a question, when large quantities of material are to be handled, whether it is best to use electric trucks or electric tractors and trailers. The solution usually depends on the conditions. For example, where the material is in packages, which have to be sorted into groups and hauled a considerable distance, or where it is an advantage to have the packages loaded on mobile trucks, as in freighthouse work, it is often more advantageous to use tractors and trailers.

Such was the case at the Roanoke, Virginia, freighthouse of the Norfolk and Western Railroad. Here, during normal times, about 800 tons of freight are handled per day. To reduce the cost of handling freight by hand, an investigation was made of the possibility of using tractor-trailer methods. It was finally decided that five electric tractors and 250 trailers could be used.

These were installed overnight by removing all the hand trucks and beginning operation the next morning with a fully motorized freighthouse. It was felt that to do this was a better test of the ability of the tractor-trailers to handle the work than to try to introduce them gradually.

Here one of the factors which had been considered as detrimental to the operation of tractor-trailers, was the narrow platforms. An investigation showed that if care were taken to plan the work so as to use a minimum number of trailers and still move the freight without re-handling or delays, interruptions or interference would be negligible. An over-supply of trailers would crowd up the platform and block the aisleways and so delay the movements of tractor-trailer trains as well as interfere with the success of the installation. In addition, excess equipment would add to the initial investment required. In contrast, it would be just as detrimental to the success of the installation to have a shortage of trailer equipment.

Shortly after this equipment had been installed it was seen that time was lost by the checking clerks while waiting for empty trailers. Instead of buying additional equipment a slight change was made in the operation, whereby, instead of permitting the entire force to go out to lunch at the same time, a few men were kept working during the regular lunch period to unload the numerous trailers that were left standing when the noon whistle blew. Previously, when the force of checkers and stowers returned to work after lunch considerable time had been lost waiting for the loaded trailers to be hauled to destination, unloaded, and returned empty. Since making the change the men find plenty of empty trailers ready for immediate use upon their return. One tractor crew is also kept at work during the lunch period to move any loaded or empty trailers necessary during this period. Shortly after this equipment was installed it was estimated that there would be a saving of 30 per cent over hand trucking costs.

In the handling of local in-bound and out-board freight the tractor-trailer system has also greatly facilitated the movement of packages to and from wagons as compared with the previous slow and expensive hand trucking, which had necessitated the handling and rehandling of shipments several times. At present an out-bound shipment is unloaded from the truck or dray directly onto a trailer and remains on the trailer until it is ready to move to the proper out-bound car. In-bound freight for delivery to local consignees is loaded from the car directly onto the trailers, which are made into a train and hauled into the freight house and stored until the truck or dray calls for the consignment. The trailers are then pulled to the door where the consignee's truck is waiting with one handling.

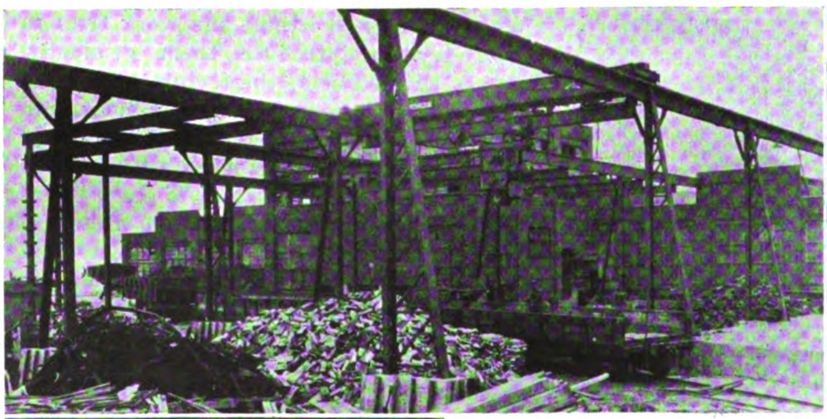
Replacing Labor in Handling Pig Iron and Scrap at a Foundry

IN MANY lines of work, particularly heavy or disagreeable tasks, it is difficult to obtain laborers, especially in times when there is a shortage of the grade known as "common labor." This is especially true with many heavy material-handling operations—particularly in yard work, as in the handling of pig iron and scrap and in other similar activities. These tasks become even more difficult in the winter time when the iron is likely to be covered with snow and ice. Such jobs, however, are often well adapted to the application of some type of material-handling equipment. In fact, there is a type of material-handling equipment for almost every type of job.

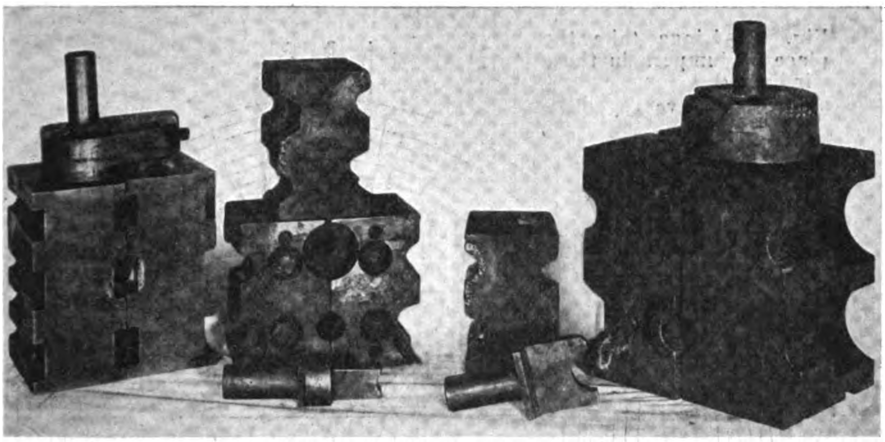
Such was the case at the Bayonne, N. J., plant of the American Radiator Company. Here the pig iron was received in gondolas and unloaded by hand, with the aid of a section of portable conveyor, as shown in the lower illustration at the left in the accompanying group of pictures. While the use of such a portable conveyor is a big saving over throwing the pigs out by hand or wheeling them away from the car, there seemed to be further opportunities for improvement and lowering of costs of handling this work. With this installation, it required the time of six men, 2½ hr. or a total of 15 man-hours to unload a car of pig iron. In addition, the distance away from the car, where the pig iron could be piled without re-handling, was limited.

An electric cage-operated, mono-rail hoist consisting of an electric hoist and cage suspended from trolleys which ride on an I-beam bridge traveling over a yard run-way, as shown in the upper two of the accompanying illustrations, was installed by the Shepard Electric Crane and Hoist Company, Montour Falls, N. Y. With this installation, two men can unload a car in one hour, a saving of 13 man-hours. In addition, the material can be stored farther from the car than was possible under the previous conditions, without extra rehandling. Of course, if the material has to be moved some distance for storage, it requires more time to handle a carload of pig iron.

In addition, the crane and hoist with the magnet are available for loading pig on the small cars used to carry the iron to the cupola. This is also a heavy job and is very disagreeable when the iron is wet or covered with snow or ice. The magnet can be used to loosen the frozen pigs as well as load them. With an overhead system such as this, a large area can be reached by the crane, which permits of a better use of the yard space for storage.



Mono-rail hoist and lifting magnet for heavy handling. Formerly, it required six men 2½ hr. to unload a car of pig iron. With this installation, two men can do the work in one hour. In addition, the hoist and magnet can be used for loading the small cars or buggies in which the pigs and scrap are carried to be melted.



Worn dies can be built up by the electric arc at a fraction of the cost of new dies.

This illustration shows worn blanking dies for making eye rods, bolt heads and similar parts, which have been reclaimed. The cost of building up these dies amounts to $5 or $10 apiece, while new dies cost from $35 to $50 each. Repairing by the arc process has the further advantage that an old die can be reconditioned in much less time than is required to make a new die.

Arc Welding and Cutting Economies

(*Continued from page 29*)

is exceedingly useful for certain applications as, for example, cutting rivets and plates for repairing or scrapping steel freight cars. The cost of cutting rivets is given in the following data, based on cutting 200 rivets, ¾ in. in diameter.

Labor, 1 hr. 3 min.—90 cents per hour	$0.94
Electric power	.80
Backing rivet stubs	.66
Total	$2.40

This is only a trifle over one cent a rivet, whereas the cost of doing the same work by other methods will average from 2¼ to 2½ cents per rivet.

A 40-ft. steel gondola car was cut up by one operator in four hours into pieces small enough for four men to handle and cut in a plate shear into small pieces of cupola charging size. The cost of the operator's labor and the electric power used was only $6.80.

Risers on steel and cast-iron castings can likewise be economically cut with the arc. For example, in one instance a cast-iron riser neck 3 in. by 9 in. was cut in 5 min., and an 8-in. by 8-in. neck was cut in 17 minutes. These cost 15 cents and 52 cents respectively, for labor at 60 cents an hour and electric power at 2 cents per kilowatt-hour.

Copper is one of the most difficult metals to cut, due to its great thermal capacity and high heat conductivity. To cut large sections of copper it is, therefore, necessary to put energy into it at a very high rate in order to produce local fusion. In one case a piece of copper slag too large to be charged into a copper cupola furnace was cut up into four sections, one cut at each side and one through the center. The side cuts averaged 1½ in. in thickness and required 2 hr. The central cut averaged 4¼ in. in thickness and required 5 hr. The cutting was all done with a current of 1,000 amp. through the arc. On the basis of labor at 60 cents an hour and electric current at 2 cents a kilowatt-hour this job cost only $15.40.

Examples of Savings Made by the Use of Arc Welding in Repairing Railroad Equipment

Steam Railroads

Parts Repaired	Cost By Old Method	Cost By Arc Welding	Saving Dollars	Saving Per Cent
Eccentric straps	$ 8.97	$ 1.19	$ 7.78	86
Cross head	27.41	2.90	24.51	89
Piston head	11.98	2.56	9.42	78
Side rods	46.74	15.58	31.16	66
Cracks in tank	26.62	2.51	24.11	90
Flues	25.56	5.11	20.45	80
Frames	84.64	12.12	72.52	86
Piston rods	7.84	1.62	6.22	79
Truck frame	5.23	1.35	3.88	74

Electric Railroads

Parts Repaired	Cost By Old Method	Cost By Arc Welding	Saving Dollars	Saving Per Cent
Gear and wheel seats on axle	$27.52	$ 9.75	$17.77	64
Journal boxes	9.00	1.86	7.14	79
Air reservoir	13.23	1.83	11.40	86
Bore of axle gear	31.69	7.55	24.14	76
Controller frame	25.00	3.58	21.42	86
Commutator shell seat	17.50	3.55	13.95	80
Space block for equalizing spring	3.85	.64	3.21	83
Draw bar carriers	2.36	.43	1.93	82
Dowel pin holes in axle bearings	9.13	.98	8.15	89

Equalizers Reduce Unbalance

(*Continued from page 26*)

of so called long and short jumpers with star, delta, and other connections were given in the article by the writer in the October, 1923, issue of INDUSTRIAL ENGINEER.

The jumpers which are shown in Figs. 2 and 3 in the form of rings are used principally on windings with a large number of poles and a large number of parallel paths such as eight, ten or twelve poles with four, five or six parallel circuits. In *M* of Fig. 2 is shown an eight-pole, two-phase four-parallel connection. In this connection one long jumper is used to connect groups 3, 1, 15, 13, 11, 9, 7 and 5 together instead of using short jumpers which would connect respectively groups 1 and 3, 13 and 15, 9 and 11, and 5 and 7. This latter arrangement would give four jumpers per phase. In addition the long jumper gives the equalizer connections already referred to in

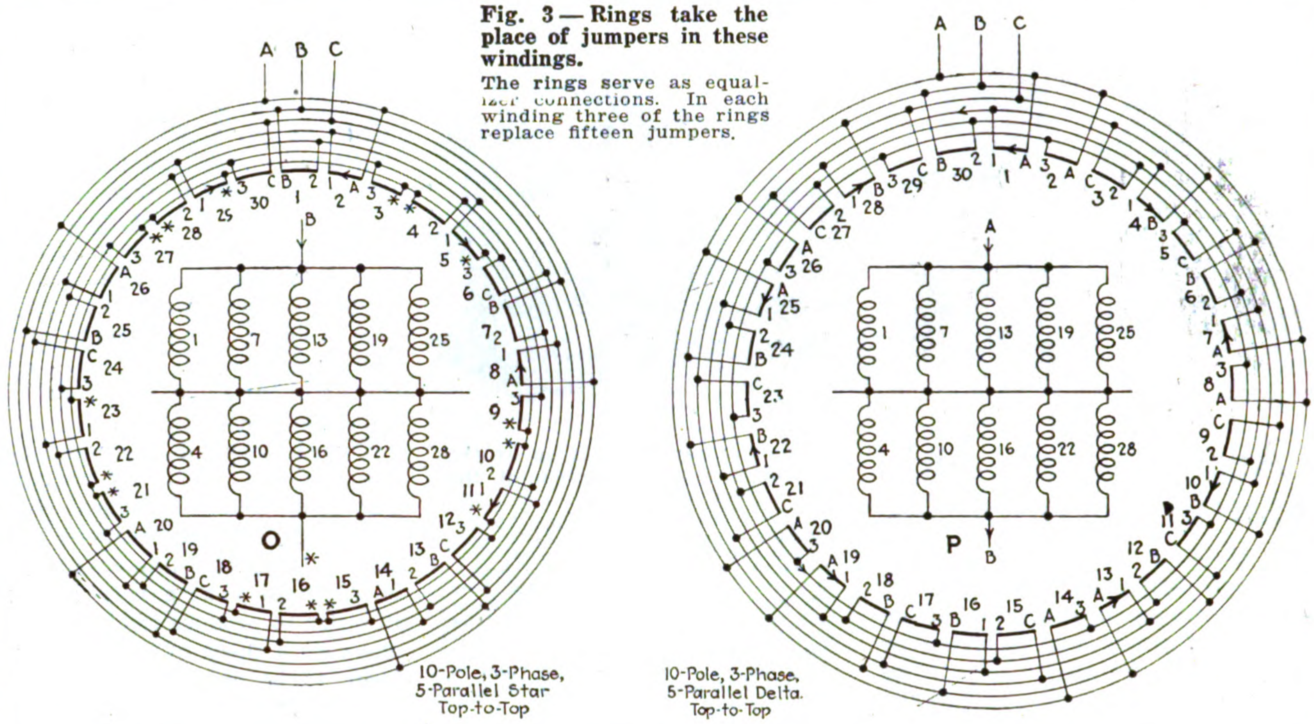


Fig. 3 — Rings take the place of jumpers in these windings.

The rings serve as equalizer connections. In each winding three of the rings replace fifteen jumpers.

the first part of this article. The long jumper also gives a better mechanical arrangement as it eliminates the crossing of group connections. In *N* of Fig. 2 is shown a ten-pole, two-phase, five-parallel diagram. There are altogether six rings, each phase having two lead rings and one jumper ring. The jumper rings serve also as an equalizer across all the five parallel paths.

In Fig. 3 are shown two more examples of ring-type jumpers. The drawing at *O* shows a ten-pole, three-phase, five-parallel star connection. For this connection there are three lead rings, one star ring which has fifteen taps to it and three jumper rings, making a total of seven rings. Sometimes the three lead rings are not used for this connection but cables are used instead. In this case the cables are made as short as possible, but they must still be rather long to connect to all five of the parallel paths. Sometimes a connection of this kind is made which seems to have only ten taps to the star ring. In this case the ends of some pairs of adjacent groups are connected together and only one lead is brought out from their junction to the star ring, thus saving time and material. This can be done between groups 3 and 4, groups 9 and 10, groups 15 and 16, and so on. In drawing *P* of Fig. 3 is shown a ten-pole, three-phase, five-parallel delta connection. This connection employs six rings, three lead rings and three jumper rings.

Reclamation Plant for Equipment

(Continued from page 23)

The rolling mill and the blacksmith shop work together in putting wrought-iron scrap into usable form. Small round and flat scrap is cut into convenient lengths and made into fagots or bundles which are heated to a welding temperature and rolled into round or flat stock. The upper of the two illustrations shows the 12-in. rolling mill. A car of fagots can be seen at the right. Behind it is one of the heating furnaces. The rolled stock is worked in the blacksmith and forge shop (below) into car and engine forgings, pinch bars, chains, bolts, etc.

brass connectors are then removed from the carbon electrodes and sold as scrap brass. The lead salts are removed from old storage battery plates and sold, while the plates themselves are melted and cast into pigs. Brass turnings and borings are passed through a Dings magnetic separator to remove iron particles and *(Continued on page 52)*

Work of Maintenance Engineers

(Continued from page 20)

ordinary or reasonable sort of a breakdown. Other duties are: 1. To organize and control the men in the department so as to keep the labor turnover to a low figure; 2. keep records on the equipment in service so as to determine frequency and cost of repairs; 3. requisition, store and disburse all material used in maintaining the electrical equipment.

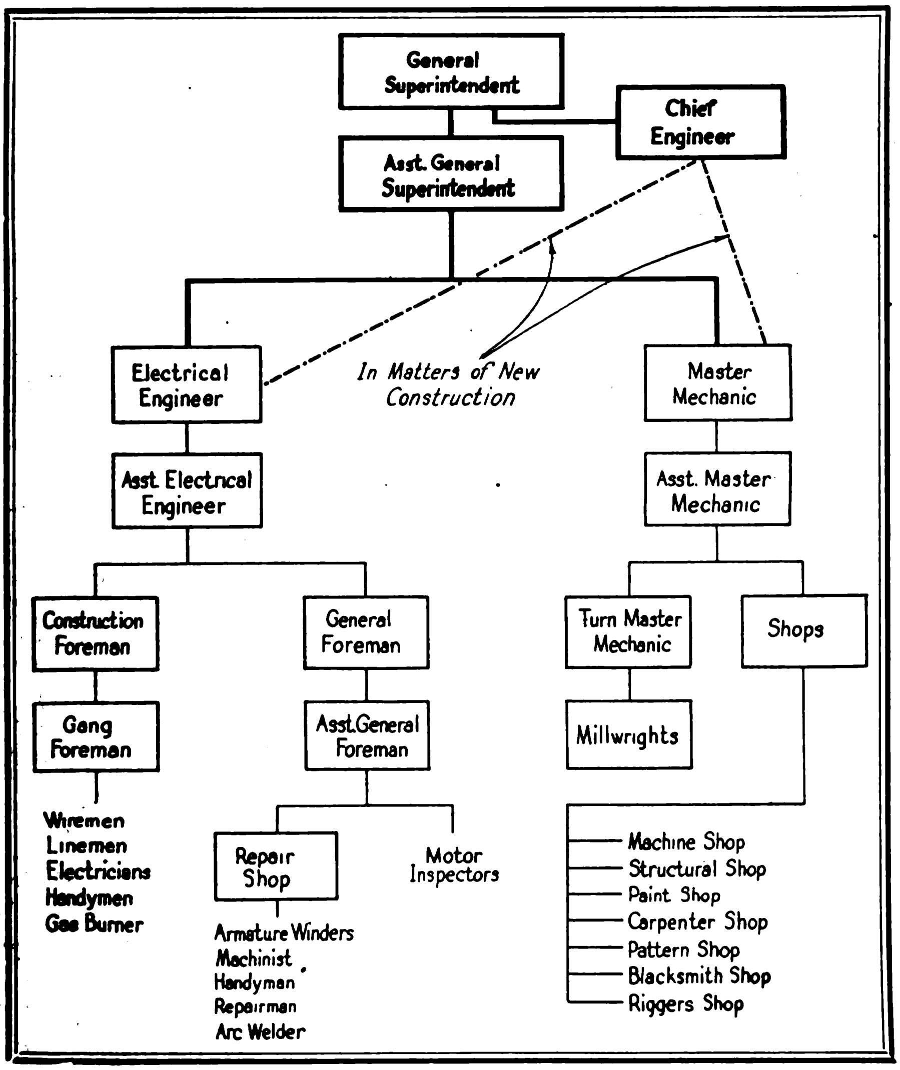
2. The lines of work that come under their supervision are as follows: 1. Design of electrical applications and layout of power distribution; 2. installation of the above; 3 operation and inspection of electrical equipment; 4. maintenance and repair of the same.

The accompanying diagram shows the department organization. As a general rule the division of work between the Chief Electrician and the Master Mechanic occurs at the motor connection to the drive. The Chief Electrician maintains the equipment from and including the point of generation or receipt of the power supply to and including the motor pinion, pulley or coupling. The Master Mechanic maintains the equipment from there on. The only disadvantage of this arrangement is that two men instead of one are held responsible for "making the wheels go 'round." Since mechanical trouble first makes itself evident by distress in the electrical end of the equipment, the electrical man usually has to first assure himself that the fault is not his and then to prove himself right he must locate the mechanical fault for the mechanical man. This results in the electrical man doing a considerable portion of the mechanical man's work. Furthermore, in quite a few plants it is a constant source of friction or buck passing.

3. The changes or rearrangements that men in charge of maintenance are most often requested to work out are as follows: 1. Make changes in the speed of a drive application; 2. make the application safer for the operator; 3. move the application to a new location; 4. improve its reliability and ruggedness; 5. extend the power distribution system; 6. extend or rearrange the lighting system; 7. design drives for new extensions; 8. design drives and power distribution for new mills.

4. The maintenance organization should have information on the following methods or repair practices: 1. Information should be obtained regarding the service and application for each type of motor and control equipment; 2. mechanical information concerning the installation of equipment, such as various forms of bedplates, motor subbases, proper meshing of gears, leveling up of armature shafts on large applications, etc.; 3. maintenance methods of locating loose bearings, worn shafts, worn pinions, and other such equipment; 4. it would be interesting to know the idea of others as to what a reasonable line of spare parts should consist of; 5. various systems and methods used in handling equipment to and from electrical repair shop, also in the repair shop; 6. system used to keep the cost of individual motors; 7. system of handling electrical stores.

Organization diagram for a large steel mill in which maintenance and construction work on 500 motors totalling 12,000 hp. is handled by sixty-five men.



W. T. Lees, Chief Electrician, Savage Arms Corp., Utica, N. Y.: The men in charge of maintenance and operation in a well organized works should be responsible for all apparatus used in connection with production from the point where electrical service begins until that power is delivered to the wheels of the machines or other appliances used in production.

2. The steam plant, shafting, belting, elevators and so on should be handled by the Master Mechanic, and all electrical work including construction, maintenance, and repairs, should be handled by the Chief Electrician, except the installation of motors and compensators, which should be done by the Master Mechanic, who is usually equipped with the necessary men and tools for this work, the installation where necessary being supervised by the Chief Electrician.

A competent force of men must be kept in the electrical department to insure continuous service. It should include men for construction work, men for inspection and maintenance and men for shop repair work. In the mechanical department there should be a gang to handle the installation of all machines, and the plant should be divided into sections with a repair man in each section responsible for all shafting, pulleys, oiling, and so forth, with a competent belt man to install, maintain, and salvage belting.

3. The most frequent changes are rearrangements of department. In our plant after the layout of machines has been received from the production department, showing the grouping of machines, the Chief Millwright and Chief Electrician will decide on the size and location of motors to handle each group. The Chief Electrician will then provide cables and panels of sufficient capacity to carry the load, and install the necessary lighting units.

L. A. Wynd, Chief Electrician, Keystone Steel & Wire Co., Peoria, Ill.: You have asked for suggestions on subjects that seem to have endless possibilities. Some of the main duties of the electrical department head in a well-organized works are:

To act in an advisory capacity to the General Superintendent on all electrical matters; to confer with the Purchasing Agent and General Storekeeper, giving the assistance of his electrical knowledge in the purchase of supplies and spare parts; to superintend maintenance and operation of all electrical apparatus by means of systematic schedules of inspection and repair; to establish and preserve a definite policy of relations between the electrical and all other operating departments, which

policy should be formulated with the idea of promoting the greatest possible harmony; and to establish a definite safety-first policy within the electrical department. This can best be fulfilled by educating electrical men up to the dangers of electrical machinery, the use of safe apparatus and strict observance of the National Board of Fire Underwriters' code.

The lines of work coming under the supervision of electrical department heads are as follows: Power distributing systems, lighting distribution, signal systems, remote- and manual-control apparatus, motors, generators, substation and power house operation, repair shop. Electrical tests on meters, motors, generators, insulation tests, efficiency tests, and so on. Distribution of power costs, estimating costs of changes or new work in the electrical system. Operation of the electrical store room.

The size of the electrical department force necessarily determines, to a great extent, the organization chart. The amount of freedom given the electrical department head to develop his organization will have great bearing on the efficiency of his department as a whole. The electrical organization should center around a man of broad practical experience in maintenance and operation. Next should come a number of key or leading men. Following the key men should come the repair men, operators, and inspectors. Some methods should be devised to train new men coming into the organization, and several men should be trained to fill any position in the department in an emergency. One plan that can be used to very good advantage to train men to think beyond their jobs is to encourage correspondence school work, and to subscribe to a good trade paper. I am getting excellent results from men in my organization who are I. C. S. students and subscribers to INDUSTRIAL ENGINEER.

The work best handled by the Chief Electrician and that handled by the Master Mechanic should be clearly defined. Experience shows that electrical work should go as far as, and include, pinions and pulleys on all motors. The Master Mechanic should take the responsibility from that point. In most plants an exception to the above is made on electric cranes, their mechanical and electrical maintenance being strictly up to the men in the electrical department.

Power and power factor surveys if carried out intelligently can be made to yield some nice returns. Substantial savings can be effected in prevention of loss of lamps by theft, breakage of the large sizes of lamps while hot by rain or snow, and vibration of lampshades. The work done by a well-organized repair department capable of pouring and machining bearings, repairing commutators and rewinding armatures and stators will save a substantial sum. The department overhauling and inspecting motors and control will, if properly organized and working systematically, show the greatest saving. This being another case of "a stitch in time."

Experience shows that more changes are necessary in the lighting and signal circuits than in any other part of the electrical system. Motor control changes, while not so numerous call for more work and effect some very fine savings in reduced burnouts. I class this change as most important.

Oscar L. Smedberg, Chief Electrician, American Car & Foundry Co., Lancaster, N. Y.: 1. The main duties and responsibilities of men in charge of maintenance are to keep the machinery in running order with the least number of interruptions and delays. Maximum production depends on this and it can be accomplished only by frequent and rigid inspection, prompt renewal of worn parts and bearing linings and seeing that all bearings are properly lubricated and kept clean. This inspection should include motors and control equipment and switches where electrical power is used. Lighting is also very important and many accidents can be avoided in industrial plants by sufficient and properly installed and maintained lighting units.

2. In the plant of the American Car and Foundry Co., Depew, N. Y., where I am employed as Chief Electrician the installation, inspection, maintenance and overhauling of electrical equipment is all handled by the Chief Electrician. Installing and overhauling of mechanical equipment is done by the Master Mechanic. Our force is divided into : (1) Armature winding and motor repair; (2) general maintenance; (3) oiling motors; (4) maintaining electric lights; (5) inspection and new installation.

3. I do not know of any changes or rearrangement that is general in all plants. Each plant has its own problems to solve.

H. M. Sherbine, Chief Electrician, Continental Motors Corp., Muskegon, Mich.: 1. The duties of Maintenance Supervisors, in my opinion, are to diagnose individually each installation, select the proper equipment, keeping in mind first cost, cost of installing, depreciation and maintenance of same. Too often we make the mistake of thinking of first cost only, which is really a minor item in the successful operation of any up-to-date plant. Competition today is keen and we are striving toward greater efficiency and higher production; therefore, we must have equipment we can keep running with a minimum of lost time.

Spending your company's money as conscientiously as you would your own, is in my estimation very important; also teaching your subordinates loyalty to the company and their fellow workmen, courtesy, efficiency, discipline and economy, eliminating to a minimum all discontent and discord and stimulating ambition, keeping them interested and impressing upon each individual how important he is to the successful operation of the plant. The reason for this is obvious for it reduces operating expense to a minimum. Do not misunderstand me here: I do not mean wages. If you pay a poor rate you can expect poor workmen and large labor turnover. Give me twenty men who are in a degree satisfied with conditions and I will accomplish as much as I will with double the number of dissatisfied men. The wide-awake man who is on the job will find places where he can keep expenses where they belong. Last, but very important, after the equipment is installed, keep it running. The production end is the heart of the plant and when it stops, due to breakdown, it is a reflection on the maintenance department and if we are going to be a success we must convince the management that we are a necessity, instead of a useless expense, which so many of them seem to think at the present time.

2. In a great many of the larger plants, the title of Master Mechanic has been discarded. The title of Superintendent of Maintenance has supplanted it. The Superintendent of Maintenance, in my estimation, should have supervision over the maintenance department, stockroom and the power house engineer who, in turn, should have charge of the power house and its employees and power house accessories; the garage foreman, who should have charge of industrial and commercial trucks, repairing and maintenance of same, also the drivers; Plant Protection Engineer, under whose supervision should come the watchmen, janitors and fire-fighting equipment; the Chief Electrician who should have the electricians, elevator operators and crane-men, battery charging and repairing, and supervision of all electrical installations, inspection and repairing of same; millwright foreman who should have charge of the millwrights, steamfitters and tinsmiths, also the installation of all machinery, hanging new motors or motor alteration after consulting with the Chief Electrician, also be responsible for shafting, belting and over-head, with the maintenance of same; the carpenter foreman should have the carpenters, painters and laborers, repairing and maintenance of all buildings, roofs and windows; the yard foreman should have the yard men and train crews. These departments should work very closely together and if the proper co-operation and harmony exist they can accomplish much.

3. This is a difficult question to answer because men in the maintenance division are quite often requested to do seemingly impossible things. One thing we are often requested to do is to re-arrange a department without shutting down the machinery. This has been accomplished successfully in our plant on several different occasions.

Archie Haist, Chief Electrician, Armstrong Spring Co., Flint, Mich.: In my opinion a man in charge of a maintenance division must first of all perfect an organization throughout his department. First, a unit should be made up to handle the oiling and inspecting. The ordinary practice is to oil every motor once a week and by instructing the men doing the oiling they can be trained to take particular notice of all conditions surrounding every installation, such as loose conduit, broken insulators and on the motors, in cases where they can be shut down, the bearings should be inspected and the belts or other drives should be looked over for any condition that is not normal. Then from that step certain provisions should be made for a gang to cover the necessary repairs that have been reported by the inspector.

Also, a testing department should be maintained and the men should be able to determine and correct the power factor problem. If armature winding is done in the plant the meter gang should have the testing of all rewound motors. This prevents the winders from slipping through something defective that might be put in service. If these four divisions of a factory maintenance department can be perfected, I think that the troubles of the

man in charge would be reduced considerably.

The Chief Electrician should not be required to move motors from one location to another, because a millwright is more thoroughly equipped for such work. Changes of speed are the most numerous and are sometimes rather hard to cover if it is impossible to change the pulleys or gears. Changes created by trying to replace a burned-out motor cover a wide range. The best method is to try to arrange for making these changes before the breakdown comes. Then the job will be more thoroughly done and is more likely to be satisfactory.

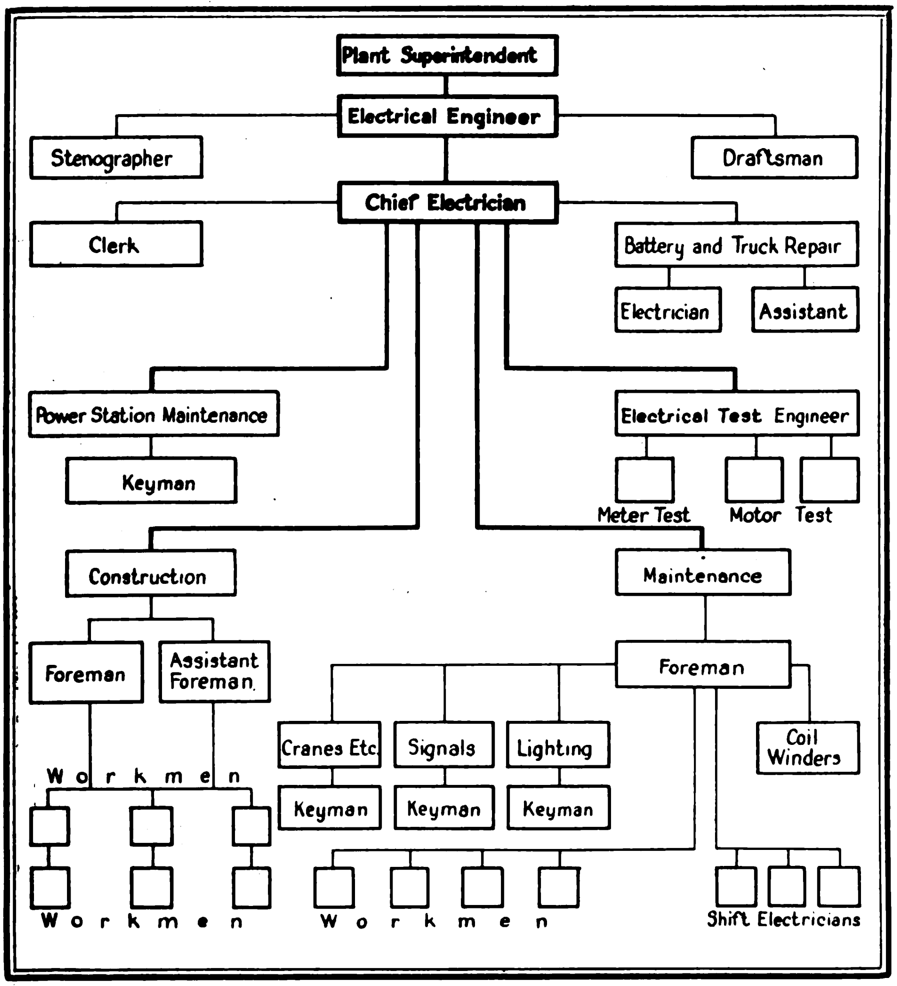
If information on conditions that might arise from a burnout could be given, such as a change from one type of motor to another, or a phase or voltage or cycle change, it might make these changes easier.

Manufacturers of testing equipment would be glad to inform persons in the use of and advantages of load and power factor testing instruments which many maintenance men would be glad to get.

J. Elmer Housley, Electrical Engineer, Aluminum Ore Company of America, East St. Louis, Ill.: 1. The duties of men in charge of maintenance work cover a wide scope. Vision, imagination and responsibility are the chief ear-marks of a good maintenance engineer. Vision is required to foresee the trend of development in the industry and to keep clearly in mind what will be needed tomorrow to replace that which is wearing out today. Imagination plays its part in adapting the best methods of other minds to one's own problems. Responsibility means, of course, that jobs which are undertaken under his supervision will be concluded efficiently, completely, and at a minimum cost. He is responsible for the initiating of repair jobs to prevent breakdowns and for repairs after breakdowns occur. He must order materials for repairing breakdowns and for replacing materials that simply wear out in service. Original designs which prove unsatisfactory must be altered so as to function properly. He must also secure the confidence and co-operation of the men in the department if a full measure of service is to be secured from them. The plant operation foremen have duties which are specialized according to industries and will not be discussed here.

2. My ideas regarding an electrical force were given in the March, 1922, issue of INDUSTRIAL ENGINEER. In connection with electrical equipment, the work handled by the Master Mechanic should be confined to lathe work, such as making bearings and turning commutators where there are only a few and he should handle the riggers which are available for all departments. In any plant large enough to require an electrical organization it is a great mistake to allow the direction of this department to come under the Master Mechanic. A man of sufficient caliber should be made responsible for the electrical division as a unit.

Electrical organization for a plant having a power generating station with 25,000 hp. connected load and employing about 100 people in electrical work.



3. From my observations I believe that the maintenance organization has equal opportunities in the electrical or mechanical divisions for making a saving proportional to the capital invested.

4. Changes most often made by maintenance men are in cases where the original installation does not function properly, due to improper arrangements and where the maintenance cost on old equipment becomes too high and where improvements in production quantity or quality may be made. In a large organization the engineering and maintenance organizations dovetail so closely that it is not always possible to make close distinctions as to where a job may begin or end.

E. D. Chrisman, Chief Electrician, Lynchburg Foundry Co., Lynchburg, Va.: The equipment of the Lynchburg Foundry Company consists of about 2,000 hp., in d. c. and a. c., 220-volt motors. The power is bought from the Lynchburg Traction and Light Company and used without transformers for operating our synchronous and induction motors in the power house that run motor-generator sets and air compressors. The 2,300 volt, three-phase, sixty-cycle power is also transformed to 220 volts, three phase, sixty-cycles for the smaller-sized motors used for general power purposes. The motors run from ¼ hp. to 170 hp., a. c., and from 1 hp. to 50 hp., d. c., both 220 volts. The motor-generators supply d.c. for our traveling cranes and small hoists and the air compressor is driven by a 2,300-volt induction motor.

The service that machinery gets around a pipe and plow foundry is very severe on account of the ever-present flying sand and dust. The equipment is handled roughly and worked to the very limit. The floor motors are used for the completion of the foundry work and for the blower for each of four cupolas.

The maintenance crew consists of two electricians, one machinist, oiler and belt man and one helper who takes care of the plow point machine heaters. The electrical equipment is oiled by the oiler and any undue noise or anything that does not look right is immediately reported to and inspected by the Chief Electrician. The operators of the floor machines are watchful for trouble and immediately notify the chief or his assistant when anything goes wrong. Daily inspections are carried on while everything is in operation; any machine that develops trouble is shut down and the chief is called and decides whether the machine shall be repaired immediately or after the day's run. The cranes are inspected by the chief or his assistant during operation and thoroughly after each day's run. The motors, controllers, shoes, brushes, bearings, brakes and brake coils especially are gone over, and any needed repairs are then made so as to have everything O. K. by morning for the next day's run.

The Superintendent and Master Mechanic are called in on any serious or heavy breakdown of a mechanical nature. The Superintendent is a past master mechanic and able to give practical advice on all mechanical troubles. The operators on the cranes help on repairs and breakdowns and are held responsible for a clean and orderly

crane. The chief has full authority and is held responsible for all electrical and mechanical equipment and has the full co-operation of the Master Mechanic in all breakdown jobs and has full power to call for any help needed to get the repairs made as soon as possible so as to get the equipment back in service.

The chief has full charge over the operation and control of the power house equipment, being held responsible for its operation. All storeroom and plant orders are issued by the chief for any electrical or mechanical repairs or supplies needed. Spare parts, such as armatures, field coils, brake coils, spare controllers, face-plate resistance contacts, segments, brushes, gears, pinions, and so on, are carried to handle most of the breakdown troubles. Spare belts are carried for all important drives. Spare motors complete are carried for all key devices and only a short time is required to unbolt one motor and bolt down the other.

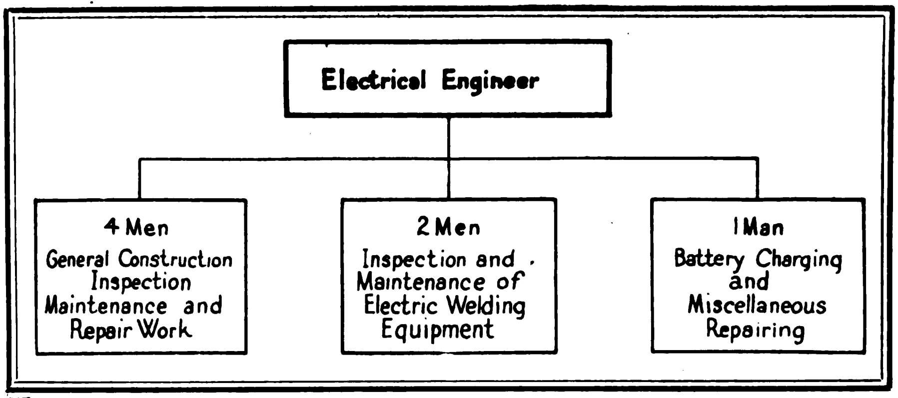
Our greatest changes are of the nature of changing motors or machines to get better results or higher production, or changes from one department to another to hasten production or add to present equipment. Other changes include switches which make it possible to operate motors on different controllers and *vice versa*, to help out in a rush or breakdown.

H. E. Reinhold, Chief Electrician, American Sheet & Tin Plate Co., New Philadelphia, Ohio.: As a Chief Electrician my duties are to make all new installations, both motor and lighting, and to order all equipment, both for new work and for repairs. I am responsible for the continuity of operation of all electrical equipment; for the prompt, economical and efficient repair of same, and for the regularity and efficiency of the inspection of this equipment.

From my experience in repairs to electrical equipment, the mechanical portions, such as truing of armature shafts, turning of commutators, making bushings and relining of babbitt bearings should be handled by the Master Mechanic, except in cases where the plant is of such proportions as to justify the carrying of a first-class mechanic on the electrical force.

A maintenance organization can show the greatest economy by a faithful, conscientious, well-planned inspection of all electrical equipment. The old adage, "A stitch in time saves nine" is nowhere better exemplified than in this connection.

The following may be irrelevant, but I believe that a little discussion of this matter in the pages of INDUSTRIAL ENGINEER might help the Chief Electrician. On several occasions in the last few years I have been called upon to make installations of electrical equipment. One just recently ran into thousands of dollars, in conjunction with mechanical machinery. In all cases the mechanical end of the job is furnished with complete details and plans but the electrical end of the job does well if the foundation bolts for the motors are shown on the general plan. With the advent of relay control for heavy and reversing motors it becomes quite a problem to take care of this after the mechanical end of the job is nearing completion. In the old days it was possible to stick a switch and rheostat almost any place at any time, but with a conduit installation and up-to-the minute equipment, this is impossible. I think it timely therefore that we of the electrical game insist that the engineers and drafting room find a place for our equipment the same as they do for the mechanical men.



Maintenance organization for metal-stamping plant having 1,100 hp. in motors.

These men ake care of all electrical equipment, including motors, of which there are 140 ranging from 1/12 hp. to 100 hp., welding machines, eight industrial trucks, signal systems, light and other equipment.

J. Jensen, Chief Electrician, Dominion Oilcloth Co., Montreal, Quebec, Canada: The duties of the men responsible for maintenance and operation in a well organized works are to see that all machinery, electrical and mechanical, is put up in such a way that every protection against accident is provided for the men who handle the machines; also to see that all machinery is kept in good running order and if possible to discover trouble and have things fixed up before an actual breakdown takes place.

All construction work, that is, new electrical installations and maintenance of all electrical apparatus, should come under the supervision of the maintenance organization. I have found that to appoint men to special duties and hold them responsible for their particular work gives the best all-round satisfaction. The men seem to take more interest in their work when they know they are wholly responsible for the continuous operation of machines under their care.

All work, mechanical as well as electrical, in connection with electrical machinery and apparatus should be handled by the Chief Electrician, and he should be held responsible. Mechanical machinery, shafting, pulleys and bearings (not motor or generator bearings), belts, etc., should be left to the Master Mechanic.

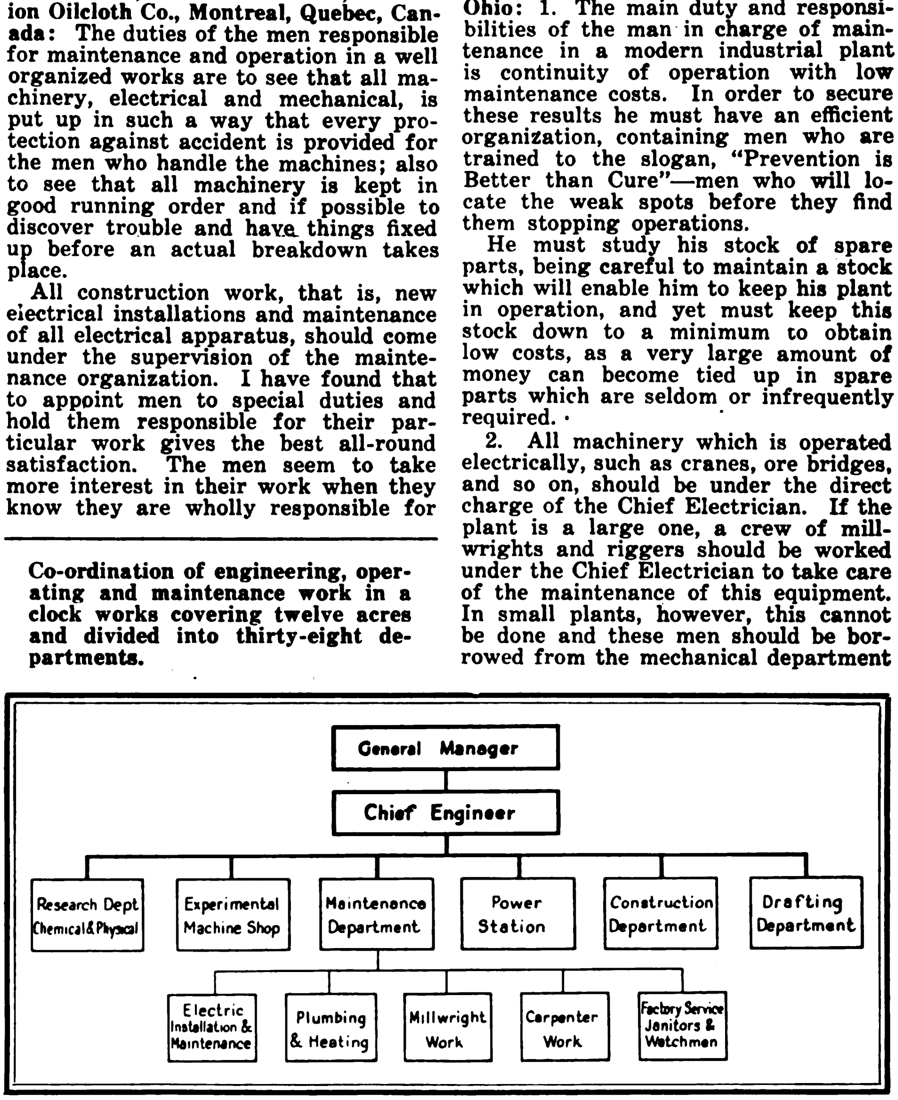
On repair work by continually being on the lookout for trouble and making the repairs before a general smashup takes place. The old saying, "A stitch in time saves nine" applies here.

O. C. Callow, Chief Electrician, The Trumbull Cliffs Furnace Co., Warren, Ohio: 1. The main duty and responsibilities of the man in charge of maintenance in a modern industrial plant is continuity of operation with low maintenance costs. In order to secure these results he must have an efficient organization, containing men who are trained to the slogan, "Prevention is Better than Cure"—men who will locate the weak spots before they find them stopping operations.

He must study his stock of spare parts, being careful to maintain a stock which will enable him to keep his plant in operation, and yet must keep this stock down to a minimum to obtain low costs, as a very large amount of money can become tied up in spare parts which are seldom or infrequently required.

2. All machinery which is operated electrically, such as cranes, ore bridges, and so on, should be under the direct charge of the Chief Electrician. If the plant is a large one, a crew of millwrights and riggers should be worked under the Chief Electrician to take care of the maintenance of this equipment. In small plants, however, this cannot be done and these men should be borrowed from the mechanical department

Co-ordination of engineering, operating and maintenance work in a clock works covering twelve acres and divided into thirty-eight departments.



as required; their work still being under the control of the Chief Electrician. This calls for very close co-operation between the Chief Electrician and the Master Mechanic, the two departments working as a unit—a thing not always found in industrial plants, but most desirable.

All motors should be installed by the electrical department and lined up by them. All pinions, pulleys and couplings should be under this department.

The average motor inspector is not as a rule a first-class rigger and millwright; so it is sometimes advisable to somewhat restrict his work to the electrical end and employ a man or two for the mechanical work.

3. In plants which shut down over the week-end, or on Sundays, there is a much better opportunity to take care of the maintenance than in plants which run continuously, such as blast furnaces and coke oven plants. A certain amount of equipment can be scheduled for overhauling on each Sunday so that everything is overhauled after a certain time and a complete record can be kept of what work has been done and when. When there is no regular shutdown period, the electrical department must keep their equipment operating and do their overhauling when a shutdown is required for other purposes. As an example: Should the air be taken off of a blast furnace for any reason, the Chief Electrician should see to it that all equipment involved in this shutdown is overhauled. A record of work which is to be done at such times should be kept. By taking advantage of these shutdowns the electrical department can get by without any delays credited to them.

4. A maintenance man may be called upon to make a great number of changes covering practically all kinds of equipment. It is not a good arrangement to have motor inspectors and maintenance men do too much construction work as they most often neglect their inspections to do this work. A small construction gang should be employed which can either be put on special work or laid off when the construction work is finished.

G. E. Christoff, Chief Electrician, Marquette Cement Mfg. Co., Cape Girardeau, Mo.: 1. The main duties of the man in charge of maintenance and operation of electrical and associated mechanical systems, may be frequent inspection of the equipment and proper instructions to the men who are under him so that they can give the equipment the best of care.

2. The line of work that would come under the Chief Electrician is all electrical installation, maintenance and overhauling of the electrical equipment. He can best organize a force to handle this work by having a man handle each particular part and see that these men are acquainted with their work. They will then do better work than they would if they were shifted from one job to another. All electrical work can be handled by the Chief Electrician and all mechanical work by the Master Mechanic.

3. The men in charge of maintenance are often requested to change or rearrange some equipment so that it will be possible to obtain greater output or the same amount of output with less expense.

A. W. Durrin, Chief Electrician, Manhasset Mfg. Co., Putnam, Conn.: 1. To provide continuous operation of equipment with the highest possible efficiency at a minimum expense, the lines of work involved are: installation, operation, inspection, repairs and supplies.

The organization of a force to handle this work will naturally vary with the size of the plant and the nature of the product. The organization chart below shows the force required for the electrical and associated mechanical equipment in a works that requires say 5,000 kw. generator capacity. In smaller plants some of these functions would necessarily have to be combined.

The regular inspection of electrical equipment is a most necessary precaution where the utmost in service is required. In a large plant it will be desirable to have men whose special duty it is to regularly (as often as daily in cases of exceptionally severe service) inspect all equipment and make minor repairs on the job. In medium and small plants, depending also on operating conditions, it can be arranged to have the inspecting done by some of the repair or construction crew.

The number of men required for repair work will, of course, depend on the size of the plant and the operating conditions. To keep repairs at a minimum presupposes a high class of installation work and intelligent and rigid inspection. If there is enough work to justify it, armature and coil-winding equipment are desirable with facilities for baking and testing.

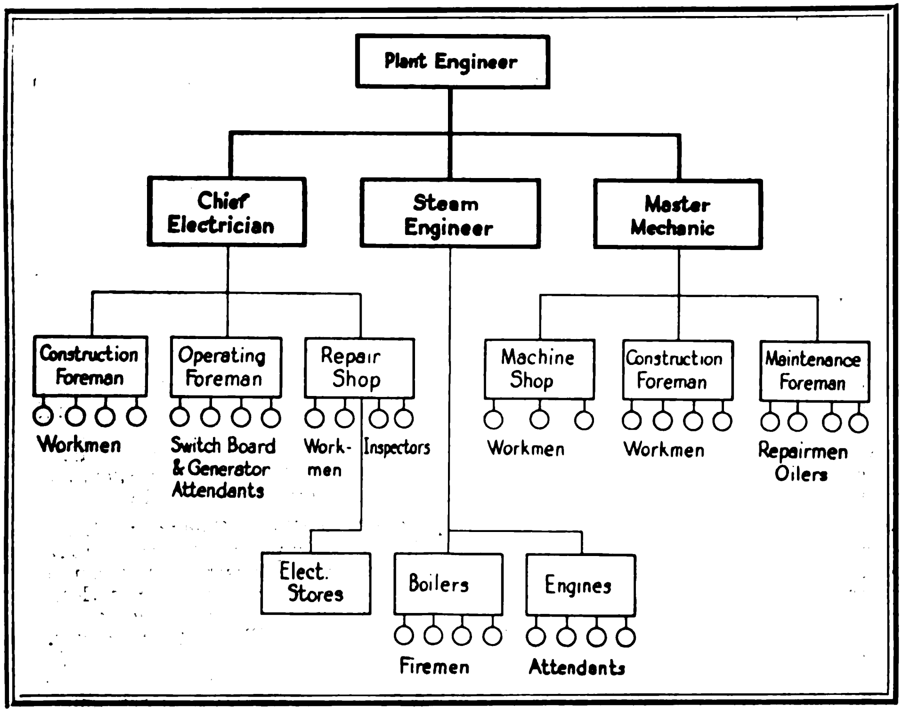
As pointed out in an earlier number of INDUSTRIAL ENGINEER a well-equipped electrical storeroom is a necessity to insure the least possible delay in getting equipment going and keeping it going. On the chart, the electrical stores are put under the repair foreman as in a plant of this size it is convenient to combine the storeroom and repair shop. Of course, the number and size of spare motors, switches and parts to be carried in stock will vary with every plant, but in every case a certain definite amount of spare equipment will prove mighty cheap insurance in keeping things a-running.

As to the work that can best be handled by the Chief Electrician and the Master Mechanic, there is doubtless room for considerable difference of opinion, but the method we have found suitable for the plant here (a textile mill using some 1,800 electrical horsepower) is as follows: The Master Mechanic sets up the machine to be driven, hangs and aligns the motor (all motors here are mounted on the ceiling) which has previously been equipped with the proper size pulleys, puts on the belt and oils the bearings. The Chief Electrician has the conduit, wiring, cut out and switch installed and connects the motor. After the proper direction of rotation is secured that particular machine is ready for production. The oiling of all motors and shafting and the care of all bearings is under the direction of the Master Mechanic. If for any reason a motor has to be taken down the fuses are pulled and the motor disconnected by the electrician, while the mechanic lowers the motor to the floor. The Chief Electrician, of course, has charge of inspecting all electrical equipment and cleaning of motors and switches, which is done periodically.

3. A maintenance organization should show the greatest saving on repair work, particularly that which involves the stoppage of work in process. A rigid inspection system, and a well-equipped storeroom backed up by a capable body of workmen can effect very great savings by reducing the delays and losses due to failure of electrical equipment to a minimum.

4. Probably this will vary greatly in different plants. Here we are frequently called upon to change from group drive to individual drive; also to install additional feeders to relieve those that are overloaded or becoming so. It is also a common occurrence to change the lighting layout to suit changed operating conditions. Much valuable information along this line has appeared in INDUSTRIAL ENGINEER.

Maintenance organization for a textile mill operating 1,800 hp. in motors.



Reclamation Plant for Equipment

(Continued from page 46)

sold. Other brass scrap is carefully classified according to the various grades and sold. The insulation is burned from copper wire and cable which is not otherwise usable, and the wire sold as scrap copper. Burned-out incandescent lamps with unbroken bulbs are often sold to lamp manufacturers. Glass, comprising broken window panes, bottles, incandescent lamp bulbs and so on is collected and sold to glass makers. The brass base of broken lamps is sold as brass scrap. Waste paper is sorted, baled and sold to dealers in this material. Burlap, felt and so on are likewise sorted and baled.

As was mentioned previously, iron and steel scrap is sorted in the yard, classified as cast or malleable iron, low-carbon steel, tool steel, and so on and disposed of to junk dealers.

After the material which comes to us has been worked over as described above and either put again into usable form or prepared for sale as scrap, there remains the problem of disposing of it, as we do not attempt to store any large quantity of supplies. This distribution is handled in the following manner: Once a month the purchasing department sends us a list of the materials and supplies which have been requisitioned by the various storehouses and other departments of the road. Items which we can supply from our stock are taken off this list. Requisitions are then issued on us by the department or storehouse which needs the material and we send it on, charging it against the department at the prevailing market price.

Scrap material is, of course, sold to junk dealers, on the highest bid.

The growth of the Corwith plant has been gradual but steady. At first only a comparatively few items of equipment and material were salvaged, but as market conditions have changed and our experience has grown we have increased the extent of our work. There are still many items which we do not attempt to reclaim, although the number is reduced from time to time. With the wide variety of material which comes to us it is sometimes difficult to decide just what should be done with a particular item. In practically all cases the answer to the question, "Can it be reclaimed at a profit?" is the deciding factor.

Trade Literature

You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

Smith and Serrell, Central Avenue at Halsey Street, Newark, N. J.—A new 32-page bulletin, 37, describes the line of "Franke Flexible Couplings for Direct-Connected Machines." This not only contains a large number of photographs of machines, in various industries, which are direct-connected by flexible couplings, but also a number of special machines which often use this equipment. In addition to descriptions of the application of the various types, a page of directions for selecting the proper size is included, as well as directions for installing the couplings and information for the user. Three pages are given over to information about direct-connected installations which show how to install, grout, align, and check up the coupling.

Foamite-Childs Corporation, Utica, N.Y. —A 16-page booklet entitled, "The Essentials of Self-Protection Against Fire," discusses the various types of portable fire extinguishers and their use on the different classes of fires. For easy reference this information is charted.

The Electric Storage Battery Company, Alleghany Avenue and Nineteenth Street, Philadelphia, Pa.—Eighteen bulletins which comprise a complete storage battery engineering and operating data book have been gathered into a spring back binder which will be distributed to electrical engineers requesting it on their official stationery. Copies of individual bulletins will be supplied upon request. Those of particular interest to the readers of INDUSTRIAL ENGINEER are: No. 159—Exide-Ironclad Batteries for Storage-Battery Locomotives; No. 160R—The Adaptability of Industrial Trucks and Tractors; No. 181—Operating Characteristics of the Lead Acid Storage Battery; No. 188—Portable Types of the Exide Battery; No. 191—Exide Batteries for Oil Switch Operation; No. 192—Exide Batteries for Portable Signal Service; No. 194—The Electric Motor Truck, Its Adaptability and Advantages; No. 195—The Exide-Ironclad Battery for Storage-Battery Locomotives; Forms 1791 and 1874 — "Facts"—two booklets which contain helpful information on the selection of batteries for locomotive service and for industrial trucks and tractors. Other bulletins in this series cover the use of batteries in power plants, railways, on power boats and in other service.

National X-Ray Reflector Company, 235 West Jackson Boulevard, Chicago, Ill.—New literature announces a special mill reflector for localized industrial lighting, as required on work benches and machines, and designed to use the T-19 bulb mill-type lamp.

The Esterline Company, Indianapolis, Ind.—An attractive 48-page booklet entitled "Do It Graphically," sets forth the advantages of graphic records as obtained through the use of Esterline graphic instruments. Some of the points discussed are: Graphic records and the executive; increasing the productiveness of labor; graphics for measurement of power; testing and recording the performance of equipment; obtaining data for design. A complete description of the mechanical and electrical elements of the meters, as well as their construction and operation is included.

Edwin L. Wiegand Company, 422 First Avenue, Pittsburgh, Pa.—Folders describe the "Chromalox" strip heaters for commercial and domestic heating. These strip heaters are used in elevators, baking and drying ovens, and for other industrial purposes.

Reliance Electric and Engineering Company, Cleveland, Ohio—Bulletin 1014 describes the Reliance Type AS adjustable speed motors of the armature shifting design for direct current. Considerable space is given to a discussion of the mechanical details and principles of operation, starting and reversing equipment, speed control, and the characteristic curves. A table of ratings and dimensions as well as a number of illustrations of actual installations are included.

Graver Corporation, East Chicago, Ind. —Bulletin 501 covers the Graver Water Filters of the horizontal pressure type.

Wisconsin Electric Company, Racine, Wis.—A number of small folders describe the "Dumore" electric small tools and motors such as portable and precision drills and a geared flexible-shaft, utility tool.

The Century Electrical Company, Syracuse, N. Y.—Circulars describe the Century armature and field testers which are specially adapted for testing new or repaired work.

Ajax Electrothermic Corporation, 636 East State Street, Trenton, N. J.—Bulletin 2 describes the "Ajax-Northrup High Frequency Induction Furnace." This consists of a 15-kva. converter and small furnace which will give a temperature up to 2,000 deg. C. This furnace is claimed to be especially adaptable for experimental work or for the preparation of small quantities of alloys.

Fulton Iron Works Company, St. Louis, Mo.—A 32-page attractively illustrated booklet describes the construction and operation of the Fulton-Diesel engine. Construction details are shown by illustrating the various steps taken in the assembly of the engine. A special chapter is devoted to fuel economy and oil consumption.

This issue is devoted to
NEW DEVELOPMENTS AND APPLICATIONS OF POWER SERVICE EQUIPMENT

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

FEBRUARY, 1924

McGraw-Hill Co., Inc.
Chicago. Ill.

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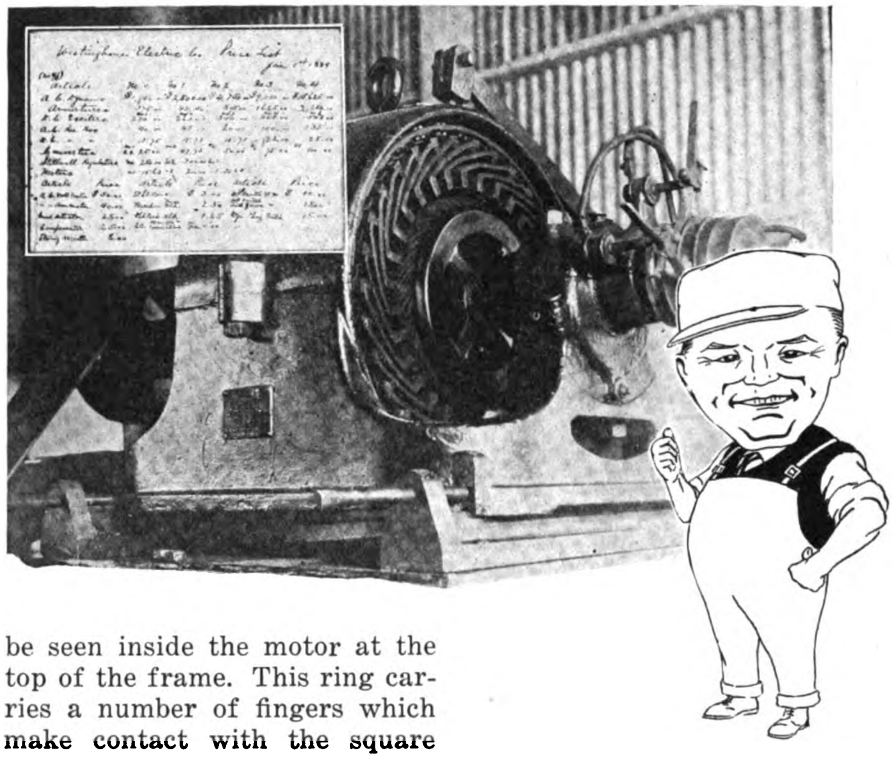
Volume 82 Chicago, February, 1924 *Number 2*



What Will a Motor Look Like 27 Years From Now?

Here's One That's Seen 27 Years of Service But Its Type Would Be Recognized Today By Only a Few Men

EVERY NOW and then evidence turns up which shows that some of the early electrical equipment was built better than the designers knew and from the standpoint of service rivals some newer designs. Here is a photograph taken in the Sacramento (Calif.) shops of the Southern Pacific Railroad of a Westinghouse Tesla type B alternating-current motor that has been in daily service for more than 27 years and is still going.

This is a 15-hp., 1,200 r.p.m., three-phase, 60-cycle motor operating at 500 volts that was installed in 1896, about two years after this design of motor was developed. It was built with a rotating primary and a stationary secondary provided with a series of U-shaped resistance grids bolted to the rear ends of the secondary bars for starting. When the rotating primary is up to speed the secondary is short circuited by moving the large lever at the top of the motor frame. This lever is connected to a large copper ring which can be seen inside the motor at the top of the frame. This ring carries a number of fingers which make contact with the square bosses at the upper ends of the cross connections. The operation of this motor was ingenious though complicated when compared with the induction design as we now know it.

With this picture we have inserted another on a somewhat different but related subject which shows that it was not a difficult matter at one time to know pretty much everything about the entire line of a motor manufacturer. This photo shows the complete price list and first catalog of the Westinghouse Electric and Mfg. Company dated January 1, 1889, a little over 35 years ago. It lists five alternators with the auxiliary equipment needed for lighting service. Only the 500, 750, 1,500 and 3,000 light machines were then available. The No. 4 unit was still a design "on paper." Today the supply apparatus catalog of this company contains something like 1,300 pages and it's no small job to keep up with the new things added every time it is reprinted.

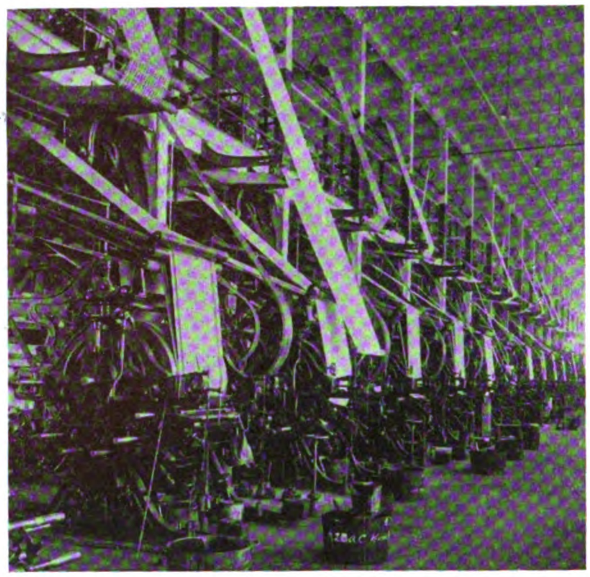
These two pictures typify the development that have attended electrification of industry during the lifetime of many of us who still call ourselves young. What will happen electrically during the next 35 years not even the wisest of us dare to predict. It is certain, however, that the electrical man then will be an extremely "wise individual" along certain lines.

Practical Pete

A Glimpse Into the

Four Plants of the Pacific Mills

Where cotton is put through the sixty-seven processes which are required to turn it into cloth. The fourteenth of a series devoted to the growth and extent of our basic American industries.



Machines for impressing the colors on printed cotton goods.

Each of this battery of forty-eight machines will print eight colors at once. The individual motor drive for each machine is located in a gallery above the machine. After it is printed the cloth goes up overhead, as shown and, after it is dry, is inspected and folded.

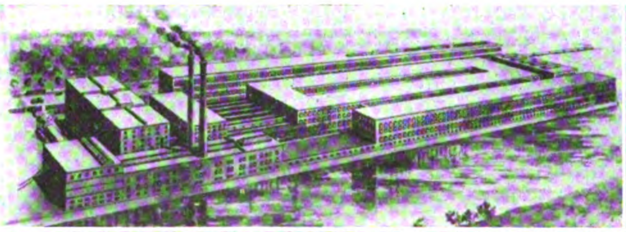
TEXTILES and textile products, according to the Manufacturing Census of 1921, is the second largest industry and ranks next to the food and food products industry. The total value of products, according to this report for 1921, was over $6,960,000,000. Although the value of the products is about a billion dollars less than of the food and food products industry, the textile industry requires almost three times as many workers, and employs about 500,000 more workers than were engaged in the manufacture of iron and steel and their products, which is the second largest employer of labor.

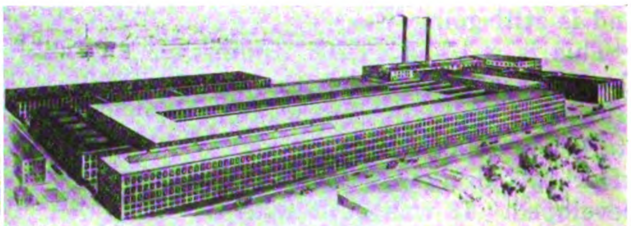
The total value of the textile fabrics and material produced in 1921 was almost $3,900,000,000; the largest single item, of course, was made up of cotton goods with a value of about $1,280,000,000. This was about 50 per cent more than the value of the worsted and woolen goods manufactured. Of the manufactured textile products mens' and womens' clothing is by far the largest item, with a value of about $934,000,000 and a little over $1,022,000,000 respectively.

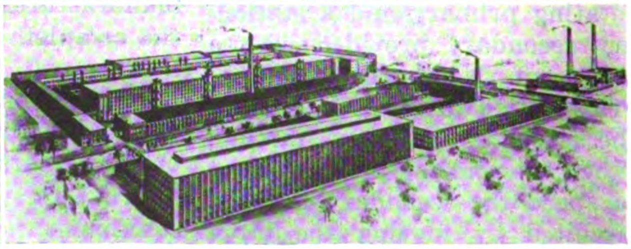
The spinning of thread and weaving of cloth was a home industry until about the beginning of the 19th century. The invention of the spinning jenny and the power loom gave an impetus to weaving, which made it one of the first factories where a large number of workers were employed. The invention of the cotton gin in the United States about 1793, enabled the cotton seed to be removed economically from the boll, so that cotton fiber could be produced in sufficient quantities to permit its use for the manufacture of thread and cloth. The manufacture of cloth has developed large industrial institutions. The manufacture of the cloth

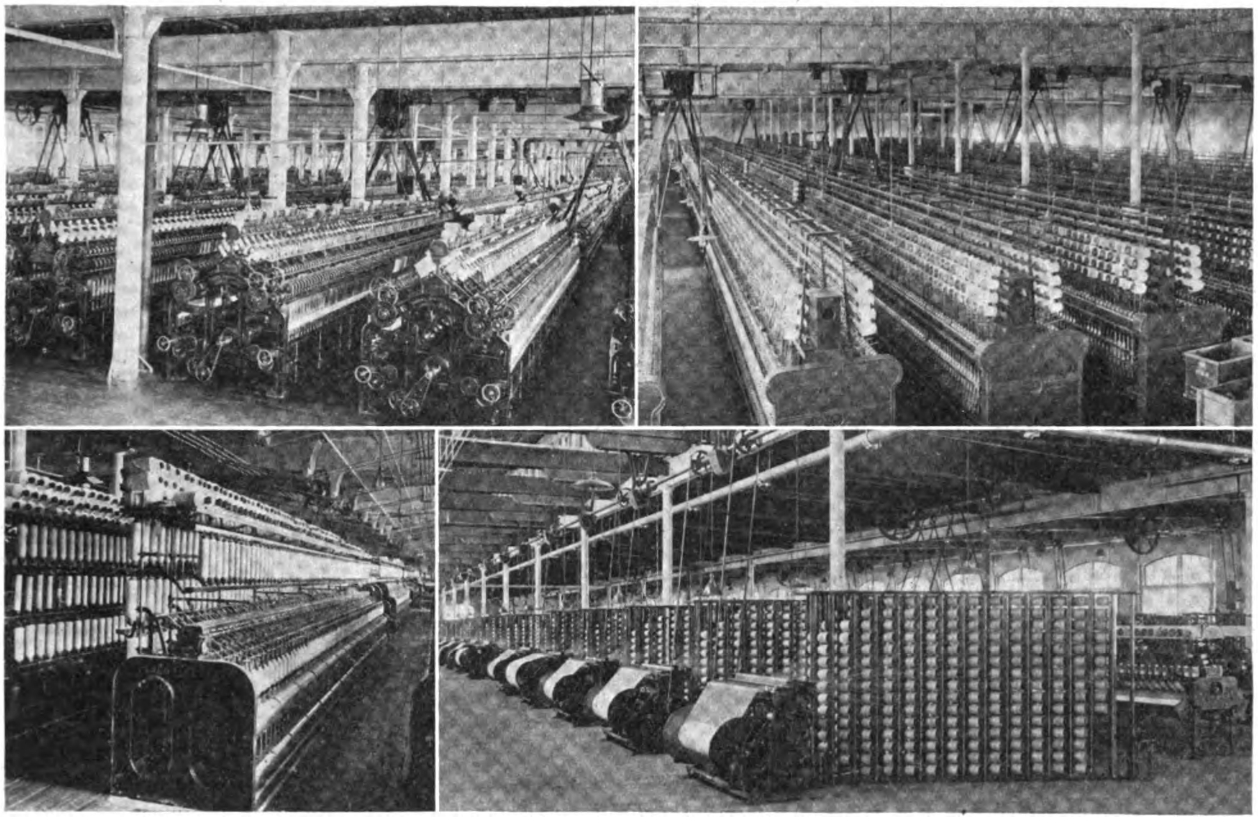
These four Pacific mills are located at Lawrence, Mass.

The Bleachery of the Print Works department contains the largest bleach house in the world with eighty bleaching kiers, each of which holds about 50,000 yards of cloth. The plant has a total boiling capacity of about 370 tons of dry cloth each day. The Print Works, upper right, contains fifty printing machines and a dye-house for printing, dyeing and finishing cotton fabrics. The Worsted department, lower left, operates 92,464 worsted spindles, 31,360 spindles for combed cotton yarns and 3,753 looms for making cotton-warp and womens' all-wool dress goods. The Cotton department, lower right, operates 184,096 spindles and 3,811 looms for making cotton cloths for dyeing, printing and bleaching. In addition to these, the company has several mills at other locations.









Views of four different departments in a Pacific mill.

The Worsted Spinning room (upper left) shows part of the 260 cap-spinning frames operated in the Worsted department. The Cotton Twisting department (upper right) shows the equipment used for making two-ply yarns. In the Cotton Roving department (lower left) the thread is wrapped on bobbins. Preliminary to weaving, the threads are wrapped on a warper (lower right) where, if a thread should break, the machine is automatically stopped.

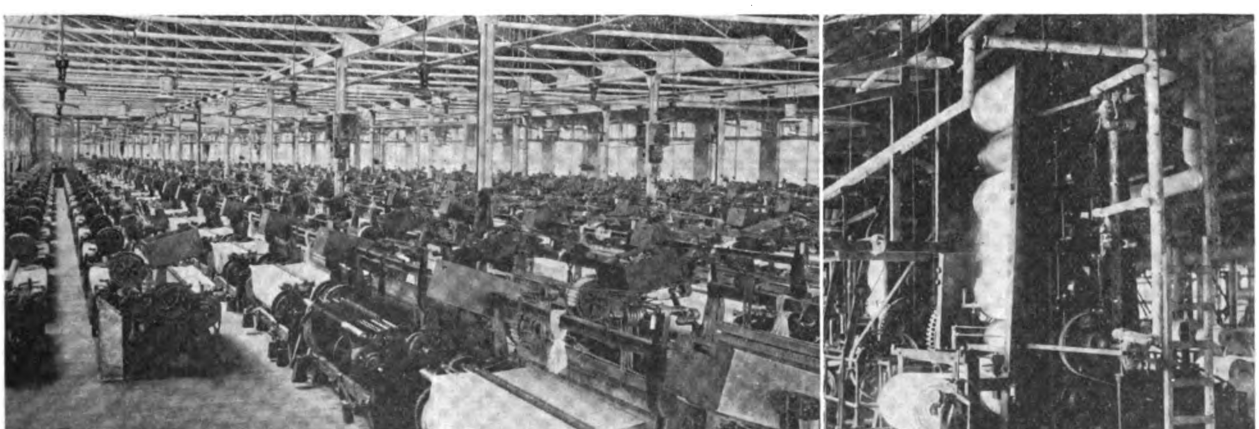
into clothing and other products, however, is, in many cases, carried on in small industrial plants. The reason for this is easily seen from the fact that the manufacture of cotton cloth, such as twill, requires sixty-seven distinct operations, from the ginned cotton to the bolt of cloth. This necessitates large investments in machinery and in raw material. The manufacture of many finished textile products, such as cotton aprons or dresses, requires a comparatively small investment.

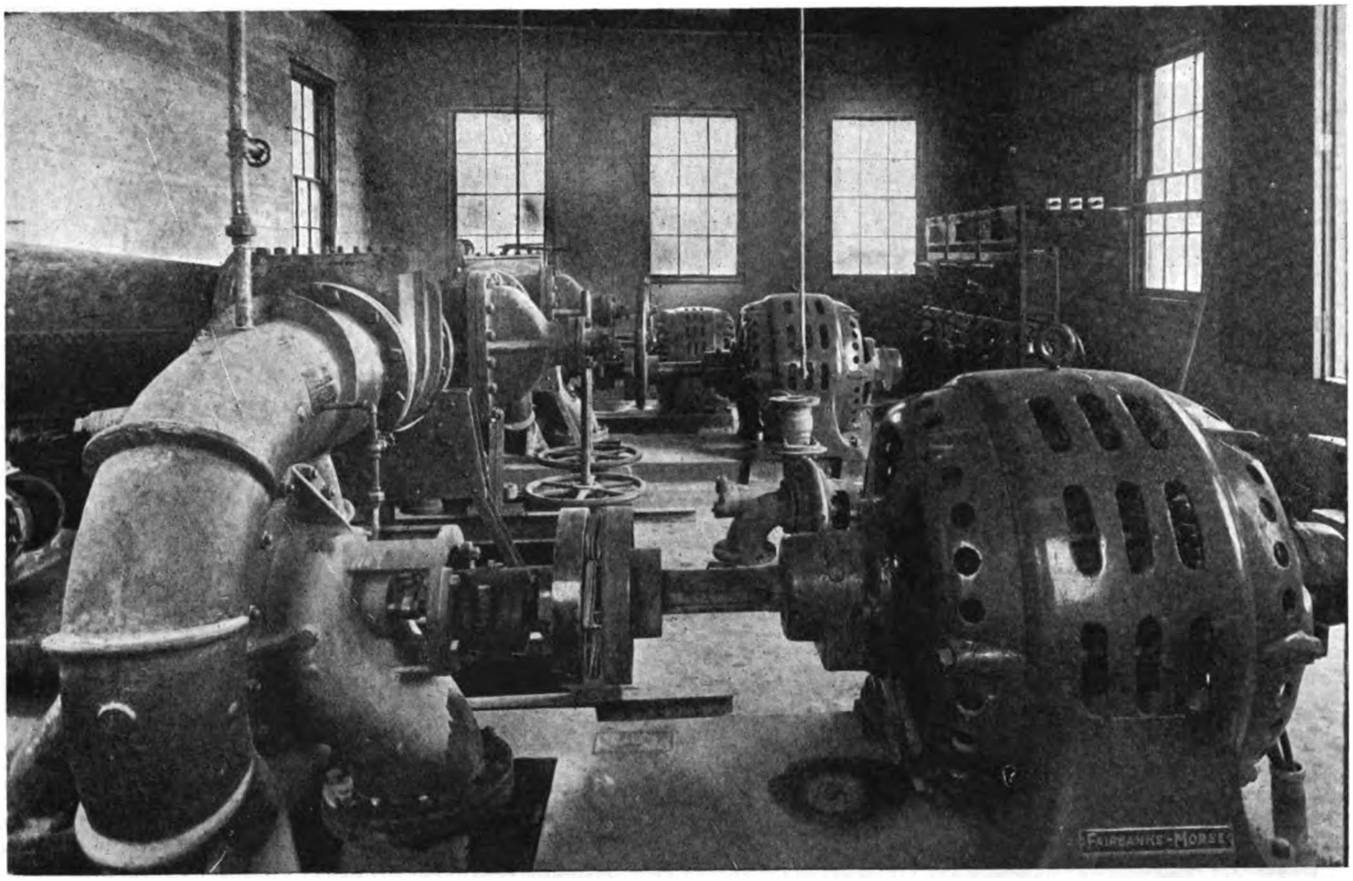
In the early days of the textile industry, most of the plants were located in the New England states. Because of the proximity to the cotton fields, many mills are now located in the Carolinas and other Southern states.

One of the largest manufacturers (*Continued on page 108*)

Weaving and finishing cloth

In the weaving room of the Worsted department (lower left) are shown some of the 3,670 looms operated. The view at the lower left shows the line of calendars in the bleached white Finishing department of the Print Works.





Service Conditions That Indicate

When to Use Group and Individual Drives

Together With Practical Operating Requirements And Supporting Data That Have Been Developed From Long Experience in Mill and Factory Work

Any machine which takes considerable power and operates at a fairly constant load not much below its maximum load should be considered for individual drive.

Such a machine should be so driven if it requires 25 hp. to 50 hp. or over. Many smaller loads can be individually driven if special conditions such as exceptionally high speed will show a saving.

By ROBERT W. DRAKE

Electrical Engineer, McCormick Works, International Harvester Company, Chicago, Ill.

A CAREFUL ANALYSIS of the reputed advantages of individual drive as compared with group drive will show that the latter has a much wider field of application than is commonly supposed. The following article analyzes the advantages of each method of drive and shows the proper field of application for each.

Twenty-five years ago, when the first applications of electric drive were being made in industrial plants, there were many cases where the logical substitute for the old engine drive was an individual drive for each machine tool. This was due to the lack of development of motors and machine tools existing at the time. In many instances, decisions were based on a careful analysis of conditions, but many other installations were made without adequate, detailed knowledge of the situation.

> THIS IS the first of three articles that will analyze the advantages of group and individual drives. The article to follow will go into detail concerning the advantages of group drive and will give an actual comparison of investment and operating costs for each. The third article will discuss points that should be considered in the installation and operation of group and individual drives.

The advantages of individual drive were evident to all but the disadvantages were much less evident. Within a few years individual drive became a fad. Many engineers who lacked actual operating experience with it, believed that a little further development in motors and control would make individual drive well nigh universal. However, as time went on and more engineers gained experience with both kinds of drive, individual drive came to be less and less generally regarded as a universal panacea.

During the past ten years alternating current has been developed so that it offers many advantages over direct current for industrial plant drives. Since alternating current lends itself to individual drive less easily than direct current, this

fact has greatly influenced the decision as to the type of drive to be used.

At present the most experienced engineers engaged in industrial power applications recognize that both individual and group drives have their places. Fifteen years' experience has convinced the writer that the field of group drive is much broader than was originally surmised. The present tendency of alternating current to displace direct current has caused machine tool builders to design machines which have a performance in group drive which closely approaches, from a production standpoint, the possibilities of individual drive.

The discussion and comparison which follows is intended to give an unbiased survey of the "present state of the art," and will offer interesting suggestions from the standpoint of design, operation and economics.

In the light of the general principles outlined in the accompanying boxed statements of reputed advantages, let us consider those applications where individual drive shows undoubted superiority before proceeding to discuss each point in detail.

Applications Where Individual Drive Shows Superiority

In heavy machine shops, locomotive shops, and the like, where the parts to be handled are heavy and crane service is desirable over a great part of the floor area, individual drive is almost necessary over that part of the floor reached by the traveling cranes. The elimination of overhead shafting and belting which interferes with the crane hook or low-hanging loads, leads to almost certain decision for individual drive in such instances.

In some cases a basement with group lineshafting on the basement ceiling offers a fair substitute, but in general, shop buildings where heavy work is done, are best built without basements on account of the heavy floor loads which must be provided for. A considerable number of heavy machines will require foundations built through the basement anyway. The fact that an indefinite number of belt openings cannot be cut through a heavy concrete floor without unduly weakening it, limits the moving of machines which normally goes on in a shop from time to time as the product or processes are changed.

At present the most frequent layout for such a shop consists of a central aisle served by overhead traveling cranes and used for machine work or erecting, or both. Such machines as are located in the central aisle are individually driven. At each side are one or more balconies. On the ground floor under the balconies and on the balconies are lighter machines doing work for which crane service is unnecessary. The majority of these machines are ordinarily group driven.

On very heavy work, such as large engine bedplates, slow speed alternator field frames, and the like, it is often more convenient to move the machine tools to the work than it is to move the work. It is self-evident that such portable machines are best individually driven.

Any machine which takes considerable power and operates at a fairly constant load not much below its maximum load should be considered for individual drive. Such a machine should almost certainly be individually driven if it requires 25 hp. to 50 hp. or over, and many similar loads requiring less horsepower can be individually driven with economy if some special condition such as exceptionally high speed will add to the consequent saving. Under the above classifications will come most large wood-planers, and most motor-driven air-compressors. Such machines can ordinarily be as-

I. Principal Reputed Advantages of Individual Drive.

A. Elimination of overhead shafting and belting.
   1. Lineshaft friction losses eliminated.
   2. Maintenance of shafting and belting eliminated.
   3. Cleaner shop.
   4. Better light.
   5. Closer speed adjustment of the tool to the work.

B. Location of machines to suit the continuity of a manufacturing process without regard to the location of lineshafting.

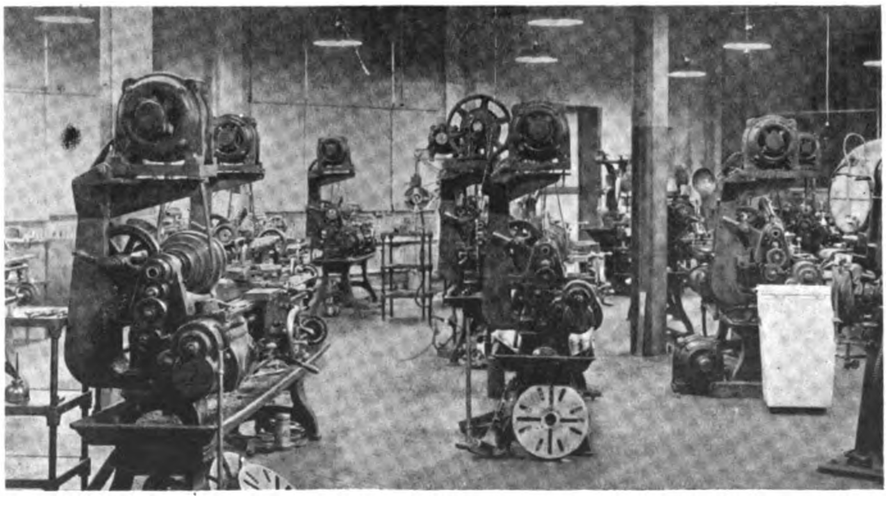
C. When only a small proportion of the installed machines is to be operated (e. g., overtime or slack season) it is not necessary to operate idle shafting and belting.

D. On large work the tool may be taken to the work instead of the work to the tool.

II. Principal Reputed Advantages of Group Drive.

A. General advantages.
   1. Lower first cost.
   2. Lower electrical maintenance expense.
   3. Breakdowns with consequent delay to production less frequent.
   4. Possible to standardize more fully on motor styles and speeds, with consequent possibility of carrying complete line of spares and resulting in greatly decreased delay from such breakdowns as do occur.

B. Particular advantages when using a.c. power.
   1. Here the lower first cost extends back through the distribution system and to the power house.
   2. If the power is purchased, this is reflected in a lower unit cost for power because of the greatly increased power factor attainable with group drive.



This picture shows some of the advantages of individual drive.

These are elimination of overhead shafting and belting, cleaner shop and better light. Since the motors operate at constant speed and all speed changes are made by pulley or gear changes, as far as production is concerned, the machines could be group driven with a consequent saving in first cost and electrical maintenance. Although the individual drive is used some of the disadvantages of belt drive are present because of the short belt between motor and lathe pulley.

Table I—Results of Tests That Indicate the Extent of Shaft and Belt Losses for Group Drives

Type of Work	No. of Counter- and Jack-shafts	Lineshaft: Speed in RPM	Lineshaft: Length in Feet	Lineshaft: Size in Inches	Hp. of Motor	Total Load: Ave. Load (Hp.)	Total Load: Max. One Hour (Hp.)	*Losses in Line-shaft Countershaft and Belts with Light Load in Hp.	Per Cent of Average Load
Foundry mills	6	200	99	2.75	50	40	53	4.00	10
Foundry mills	6	200	99	2.75	50	25	42.5	3.00	12
Wood working	5	300	40	2.75	50	45	80	7.35	16
Cordage and twine	2	....	18	3.375	40	35	....	3.80	11
Heavy grinding	3	200	240	2.75	100	80	110	7.20	9
Canvas making	11	225	75	2.00	5	3	8	0.212	7
Canvas making	11	225	59	2.00	7.5	5	....	0.562	11
Press work	7	200	45	2.375	7.5	7	17	3.32	47
Wood pattern shop	11	200	50	2.375	15	11.5	....	1.55	10
Forge shop	14	200	267	2.375	100	100	130	12.50	13

*The hanger bearings are not of the ball or roller type, but are self-oiled, babbitt-lined sleeves fitted with wicks and oil cellars. Practically none of the countershafts has ball or roller bearings. The majority are of the ordinary tight and loose-pulley variety. Special countershafts where necessary were generally purchased with the driven machines, and are of various types. The shafting is of ample size for the work.

sured a steady load approaching capacity by shutting down units.

Belts cannot be operated at any desired speed. Beyond approximately 6,000 ft. per minute the tendency of the belt to leave the pulley, due to centrifugal force, greatly reduces the power which it transmits per unit of width. If the power to be transmitted is considerable, any attempt to offset this by reducing pulley diameters leads to undesirable or impossible drives due to the increased belt width required. To a certain extent silent chains extend the speed range, but they are by no means universally applicable.

Some machines when most economically designed run at so high a speed that operation from a group lineshaft is inconvenient or impossible. If they offer a fairly steady load approaching their maximum load they can be individually driven to advantage. If they do not offer such a steady load, but their horsepower requirements are considerable, there is often no reasonable alternative but individual drive.

Such drives include centrifugal pumps, especially those requiring more than 15 hp. or so, centrifugal compressors, centrifugal gas boosters and the like, which are usually designed for the highest practicable speed. In this class are also most fans, blowers, and exhausters of considerable size, although in some cases a blower or exhauster of moderate size can be grouped to advantage with the machine which it serves.

A discussion of the reputed advantages of individual drive will now be undertaken.

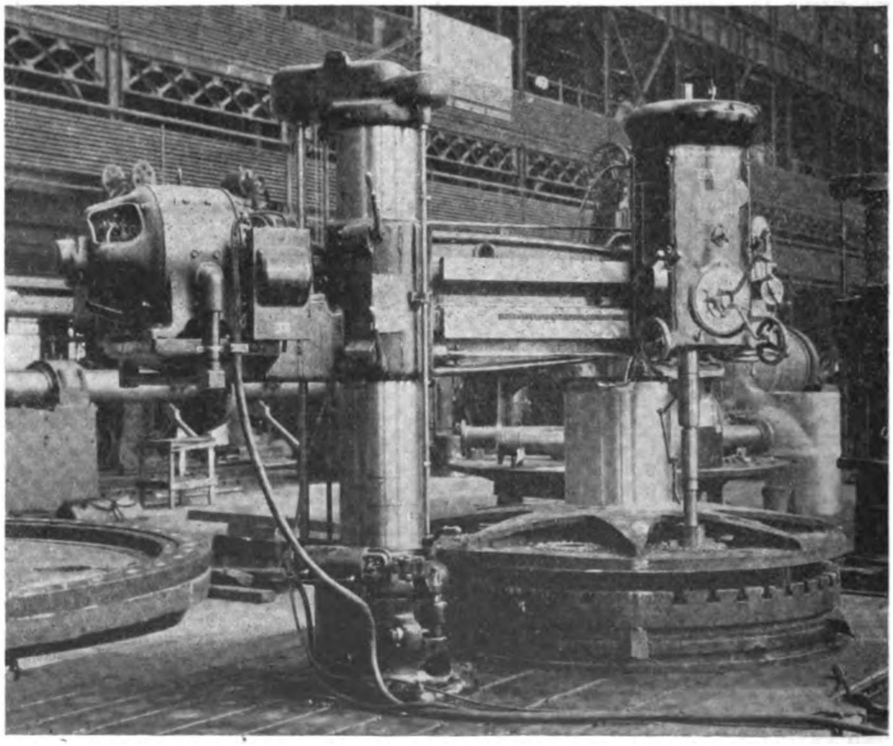
A. ELIMINATION OF OVERHEAD SHAFTING AND BELTING.—When it is desired to eliminate overhead shafting and belting, individual drive is the best solution.

1. Elimination of Lineshaft Friction Losses.—These losses have been stressed by many authors as one of the outstanding advantages of individual drive. The saving of power from this source is more fancied than real because various factors combine to reduce the average motor efficiency of individual drives to an extent which frequently more than offsets the shafting and belt losses in the equivalent group drive.

In certain industries, elimination of dust and dirt is an essential part of operating conditions.

Individual drive makes possible a cleaner shop than does group drive. In such industries as the food or textile, gains in this respect are worth considering and may even be a controlling element of choice.

To give an idea of the ordinary magnitude of shaft and belt losses, I have tabulated results (shown in Table I) of a number of tests on representative group drives. This shafting is not "modern" by any means. The hanger bearings are not of the ball or roller type, but are babbitt-lined sleeves fitted with wick self-oilers and oil cellars. Of the countershafts practically none has ball or roller bearings. The major-



ity are of the ordinary tight- and loose-pulley variety. Special countershafts where necessary were generally purchased with the driven machines, and are of various types. The shafting is of very ample size for the work. In general, I believe that this practice reduces friction, where shafting is carefully aligned, through the reduction of deflection from belt stresses.

Weighted for capacity of drive, the average losses in line-shafts, countershafts, and belts in group drives in this shop appears to be approximately 12½ per cent. The actual loss is probably nearer 16 per cent, for belt losses increase with load. For comparison with this we must approximate the difference in average motor efficiency between individual drive and group drive.

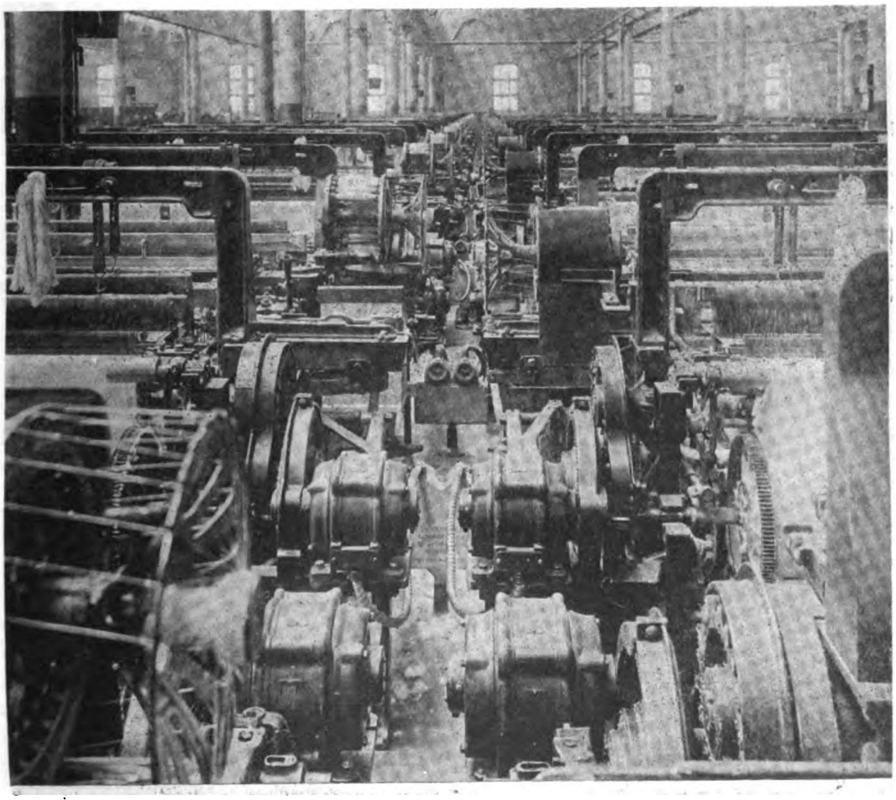
The average motor efficiency of an individually-driven group of machines is considerably lower than that of the same machines group driven because the average motor is much smaller, and smaller motors are less efficient.

It is well known that the total horsepower of motors necessary for individual drive is far greater than that required for an equivalent group drive. An individually-driven machine must be driven by a motor capable of doing the heaviest job which will ever be done on the machine. The machine is seldom operated at this maximum, and the machines in the group are never called upon for maximum output simultaneously. A group drive requires a motor large enough to carry the heaviest average continuous load on the group. For example, in wood working, an individually driven matcher must be motored for very heavy reduction with dull knives on poorly seasoned hardwood, for such a job will sometimes occur. But it is most unlikely that in a group of wood-working machines, many will ever be working simultaneously at such jobs. In fact with many group drives it can be safely assumed that some machines will be down for setting up a new job, sharpening tools, inserting stock, checking dimensions and the like. The short-time overload capacity of the motor will bridge over periods when this is not true.

The ratio of installed motor capacity for individual drive to that for group drive of the same machines, varies for different sorts of driven machines from five to two. Five is common where the manufacturers' recommendations as to motor sizes are accepted without study and two is exceedingly uncommon. For example, in several cases detailed information as to the work to be done was furnished to the principal American manufacturer of heavy machinery in his line. The work is such that a large part of the time is required for getting work in and out of the machine which he recognized, as evidenced by his estimates of daily production. The machines are built with a heavy flywheel to bridge the instantaneous peaks of power demand, but the manufacturer's recommendations as to motor rating for the job proved on subsequent tests to equal the maximum instantaneous load on the motor lasting less than 3 per cent of the time. Four of these machines have been running for several years, individually driven by motors of 20 per cent of the recommended capacity without any repairs. The motors run cool and could well be smaller still.

Portable machine tools, such as the one shown, must of necessity be individually driven.

On heavy work, such as large bedplates, alternator field frames and the like, it is often more convenient to move the machine tools to the work than it is to move the work.



Probably as good an average as any, for existing installations in the metal machinery industries, is that given in "Machinery's Encyclopedia," Vol. 4, page 441, as follows: "Actual experience has shown that for group driving an ordinary machine shop, a motor of one-fourth to one-fifth the total horsepower of the motors required for the individual machines is sufficient."

The writer's experience is, that for many routine manufacturing applications, not jobbing nor manufacturing which approaches jobbing in its variety, this can by very careful engineering be made one-third.

Thus we may assume for comparison, on the average, motors in individually-driven groups where the engineering has been exceptionally good, will average 30 per cent full load. In a group-drive plant where equivalent engineering skill has been applied to the choice of motor sizes, group-drive motors will usually be of normal or 40 deg. rating. They will be so chosen that at periods of maximum load on the group, they are overloaded 25 per cent or more, according to the capabilities of the individual styles and sizes, and the time of year when the maximum load is likely to occur. The average all-year load on such a group-drive motor in a plant having some variation in business may be assumed to be between 75 per cent and 100 per cent full load, say 87 per cent. This amounts to 70 per cent of the maximum load during the busy season.

Motors for individual drives must in general be slower in speed than motors of corresponding capacity used in group drives. Slow-speed

Table II—Typical Performance of Sixty-Cycle Alternating-Current Motors

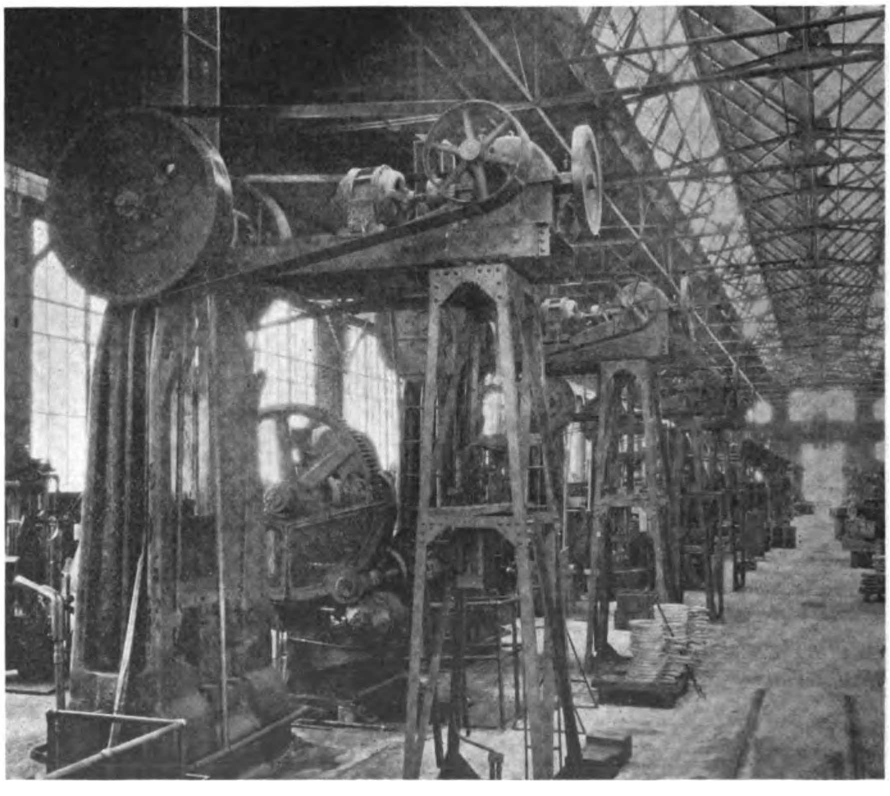
Motor Rating in Hp.	Speed in RPM.	Operating Characteristics of Motors			
		87% of Load		30% of Load	
		Power Factor in Per Cent	Efficiency in Per Cent	Power Factor in Per Cent	Efficiency in Per Cent
1	600	52.5	72	24	52.5
	1800	71	84	29	72
5	600	68	83	35	70
	1800	86	86	57	79
25	600	80	89	67	83
	1800	89	90.5	47	83
100	514	82	91	54	83
	720	87	91	60	84

The extremes of speeds shown in the above comparative tabulation are chosen to emphasize the comparison. It is realized that average speeds of group drive and individual drive motors are ordinarily somewhat less unlike.

motors lend themselves better to efficient and reliable gear drives, and even when a motor is connected to an individually-driven machine by a belt, the belt is likely to be vertical, the centers short, and the maximum possible size of driven pulley limited, so that conditions are unfavorable for a high-speed motor. The efficiency of slow-speed motors is generally less than that of high-speed motors of the same capacity.

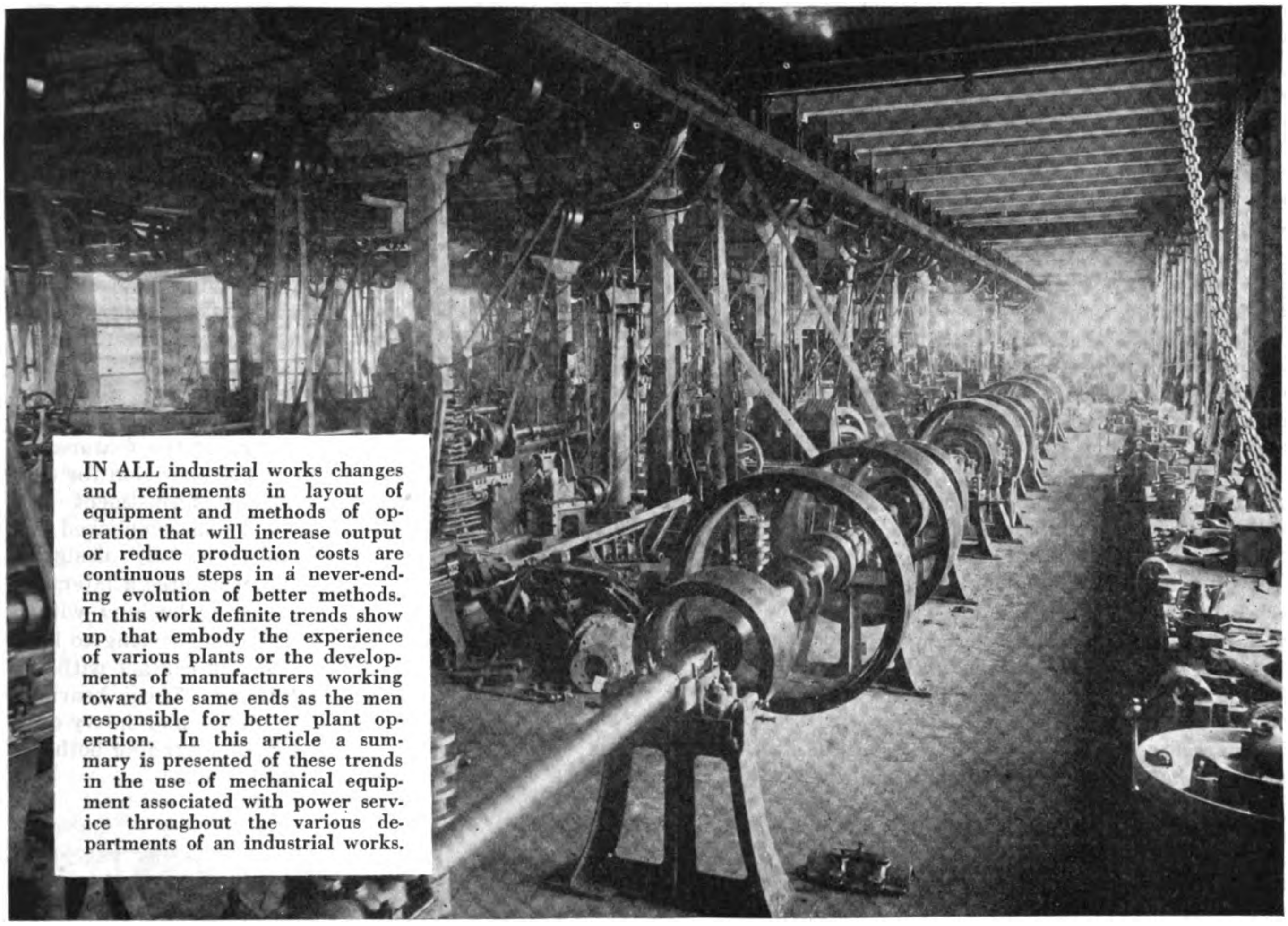
In Table II is given a condensed outline of performance which is characteristic of modern 60-cycle alternating-current motors. The relative speeds in the table are in more extreme contrast than in average practice. In practice 60-cycle alternating-current, constant-speed motors used on group drives have an average efficiency (weighted for size of motor) of approximately 86 per cent and the average efficiency of similar motors as used in individual drive is 75 per cent. Actually this latter figure is high for most large plants due to the fact that the average motor in a large plant where good engineering has been used in the electrical design, operates above rated voltage. The starting torque of squirrel-cage, induction motors (which are very generally used in such plants) as ordinarily designed, is as low as is practicable. In fact during the last ten years in an effort to obtain higher efficiency, the tendency has been to reduce the starting torque so much that the motors are unsuitable for many drives; hence motors with special high-resistance rotors are necessary. If one wishes to "stick to standard" motors to keep down the necessary stock of spares, it is necessary, on some drives, to reverse the connections of the starting compensator, so that the motor starts on a voltage higher than full line voltage. The starting torque of an induction motor varies as the square of the voltage; therefore the voltage must be at least maintained at rating on all motors, and as a consequence, in a large plant the motors near the power houses or substations are operated at say 10 per cent over-voltage. The average motor may therefore be said to operate at 5 per cent over-voltage. This 5 per cent over-voltage has a negligible effect on the efficiency of the group-drive motors operating near full load, for the effect on the two principal losses, the losses in the copper and iron, approximately offset each other, but for the individual-drive motor operating on the average at only 30 per cent load, the efficiency is lowered about 1 per cent for our hypothetical average motor.

Hence we see that for constant-speed, alternating-current motors the loss in motor efficiency of individual over group drive is in the order of 12 per cent and just about offsets the additional lineshaft, belt and countershaft losses of group drive. The efficiencies of direct-current motors at fractional loads are decidedly lower than the efficiencies of corresponding alternating-current motors. Thus, constant-speed direct-current *(Continued on page 106)*



A hammer drive such as the one shown does not readily lend itself to group drive.

This is because the motor is required to slow down when the load peak occurs and thus permit the flywheel to supply the peak load. The result is a more even power demand and permits using a smaller motor than would otherwise be required. The intermittent operation of the individual units is another argument for individual drive.



IN ALL industrial works changes and refinements in layout of equipment and methods of operation that will increase output or reduce production costs are continuous steps in a never-ending evolution of better methods. In this work definite trends show up that embody the experience of various plants or the developments of manufacturers working toward the same ends as the men responsible for better plant operation. In this article a summary is presented of these trends in the use of mechanical equipment associated with power service throughout the various departments of an industrial works.

Trends and Practice In the Use of

Mechanical Devices in the Path of Power Service

Throughout Industrial Works Together With Details of Recent Developments by Those Companies Which Are Making This Class of Equipment

By G. A. VAN BRUNT

Managing Editor, Industrial Engineer

IN THE INSTALLATION and application of power service equipment, distinct trends and tendencies which are of interest to those who are responsible for the operation and maintenance of such equipment have been manifested during recent years. These trends, in many cases, have created new devices or improvements on existing equipment, designed to give increased operating efficiency, greater reliability of operation and a reduction in maintenance costs. Some of these tendencies, together with developments typical of improved practice in the use of power service equipment will be discussed in this article.

Starting with the motor, as the source of power, present practice tends to the use of higher motor speeds than were formerly used. This is largely due to the fact that a high-speed motor is, in general, smaller and cheaper in first cost than a low-speed motor of the same horsepower rating. Also the introduction of higher working speeds in production machines themselves has gradually resulted in a general increase in driving speeds, with consequent increase of production per unit.

Along with increased motor and machine speeds have come higher line and countershaft speeds. Whereas the practice formerly was to keep lineshaft speeds down to somewhere around 100 to 150 r.p.m., which naturally involved the use of large pulleys on the lineshaft, the tendency now is to run the lineshaft from 225 r.p.m. to 300 r.p.m. and use smaller pulleys. In this way the necessity of getting a large reduction in speed between motor and lineshaft and then securing a large increase in speed between the lineshaft and the production unit is avoided.

Higher line- and countershaft speed means, however, increased friction and wear of bearings. To offset these disadvantages increasing use is being made of antifriction, ball or roller, bearings. The increased application of these types of bearings is not, of course, confined to lineshafts, but embraces a wide variety of equipment.

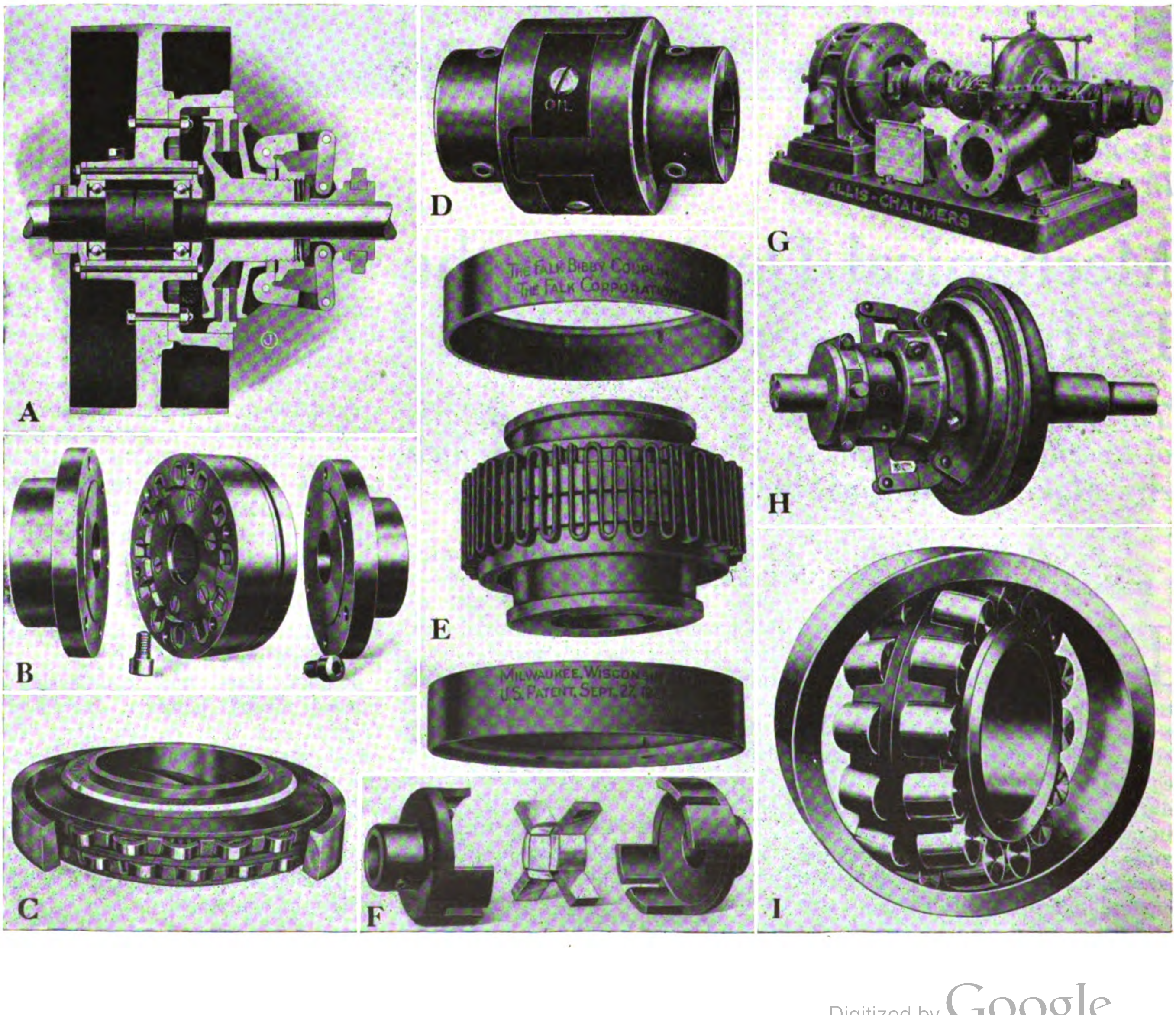
Bearings and Bearing Metals

As examples of the new designs of antifriction bearings which have been brought out recently, mention may be made of the spherical type roller bearing developed by SKF Industries, Inc., and a disk-roller bearing put out by the Whitney Disk-Roller Bearing Company.

The new SKF bearing, which follows closely the design of the self-aligning ball bearings made by this company, contains two rows of rollers, each of which has convex sides so that its periphery is curved in two planes. The outer race is ground spherical over its inner surface so that it can be slipped over the rollers. The inner race has two concave surfaces in which the rollers fit and make contact for their full length. Between these surfaces is a guiding flange. The shapes of the parts and the action of the forces cause the inner ends of the rollers to bear against the flange, which maintains them with their axes parallel to that of the shaft. The bearing is self-contained and self-aligning and has, it is claimed, the ability to carry a thrust load of considerable magnitude.

The application of this bearing to railway motors, railway journal boxes, paper machines, hoisting machinery, rolling mills, rolls and flywheels, flour mills, flaking mills, steel mill motors, electric railway motor-generators, log frame saws, rotary furnaces, tube mills, and a number of miscellaneous applications, has proved that it is well adapted to the requirements of heavy-duty service.

The Whitney disk-roller bearing is a two-point contact bearing and consists of a cage containing disk-shaped rollers which are laterally guided and supported between adjustable bearing members, a cup and a cone which have conical faces of equal angle. One of the features of this bearing is the provision for constant, automatic adjustment for wear. This is accomplished by means of an especially designed spring which constitutes a laterally-expanding sleeve or bushing within the bore of the cone, serving to keep all of the rollers in contact with the races at all times. These bearings are made in light- and heavy-duty types, and for withstanding both radial and thrust loads.



New developments in mechanical equipment of interest to industrial engineers.

(A) Lemley friction-clutch, ball-bearing pulley manufactured by W. A. Jones Foundry and Machine Co., Chicago, Ill. (B) Francke high-speed-type flexible coupling, Smith & Serrell, Newark, N. J. (C) Whitney disk-roller bearing made by Whitney Disk-Roller Bearing Co., Chicago, Ill. (D) Higgins flexible coupling made by the Tomkins-Johnson Co., Jackson, Mich. (E) Falk-Bibby flexible coupling manufactured by The Falk Corporation, Milwaukee, Wis. (F) Francke fractional-horsepower flexible coupling developed by Smith and Serrell, Newark, N. J. (G) Underwriters' single-stage fire pump, made by Allis Chalmers Manufacturing Co., Milwaukee, Wis. (H) Lemley friction clutch manufactured by W. A. Jones Foundry and Machine Co., Chicago, Ill. (I) Skayef roller bearing made by SKF Industries, Inc., New York, N. Y.

The various types of ball and roller bearings, with details of their installation on lineshafts and in motors, were described in the September, 1922, issue of INDUSTRIAL ENGINEER. Further information on the use of ball and roller bearings in motors will be found in the report of the special bearing committee of the Association of Iron and Steel Electrical Engineers given at the Buffalo convention of the association, which was reported in the October, 1923, issue of INDUSTRIAL ENGINEER.

The following companies have been prominently identified with the development of ball, roller and similar type bearings:

American Roller Bearing Co., Pittsburgh, Pa.; Auburn Ball Bearing Co., Rochester, N. Y.; Bower Roller Bearing Co., Detroit, Mich.; Chicago Pulley and Shafting Co., Chicago, Ill.; Fafnir Bearing Co., New Britain, Conn.; Hyatt Roller Bearing Co., Harrison, N. J.; Nice Ball Bearing Co., Philadelphia, Pa.; Norma Company of America, Long Island City, N. Y.; Schatz Manufacturing Co., Poughkeepsie, N. Y.; SKF Industries, Inc., New York, N. Y.; The Ball and Roller Bearing Co., Danbury, Conn.; The New Departure Manufacturing Co., Bristol, Conn.; United States Ball Bearing Manufacturing Co., Chicago, Ill.

A roller-bearing countershaft box has been developed by the St. Louis (Mo.) Machine Tool Co. for use with its products. The box is fitted with an adjustable taper roller bearing, and has suitable sockets so that it will fit in standard hangers. The back of the box is solid, while the front has the usual style of end plate.

Considerable attention has also been paid to the development and production of better bearing metals for plain bearings. Among the new bearing metals may be mentioned Stewart Brons, made by the Stewart Manufacturing Corporation, Chicago, Ill. This is a copper-lead alloy the components of which will not, it is claimed, segregate on repeated melting and cooling. On failure of lubrication it is said that this metal sweats a small amount of lead when it reaches a temperature of 600 deg. F., and thus becomes self-lubricating. The melting point of the metal is 1,700 deg. F.

The American Metal Products Co., Milwaukee, Wis., has also recently produced what is known as Ampco bronze. This bronze is made in several grades of hardness and is intended for use in the manufacture of bearings, gears, worms, and so on.

Agrilite bearing metal, manufactured by the American Injector Co., Detroit, Mich., is another recent development. This is a bronze consisting of copper, tin and lead, with the lead content high enough to produce the self-lubricating property.

Belting and Pulleys

In line with the general increase in lineshaft and pulley speeds, belt speeds have likewise been increased somewhat. There is, also, a growing tendency on the part of belt users to devote more attention to reclaiming and rebuilding old belting. In this way the useful life of a belt can be considerably extended. Several firms are specializing in this work.

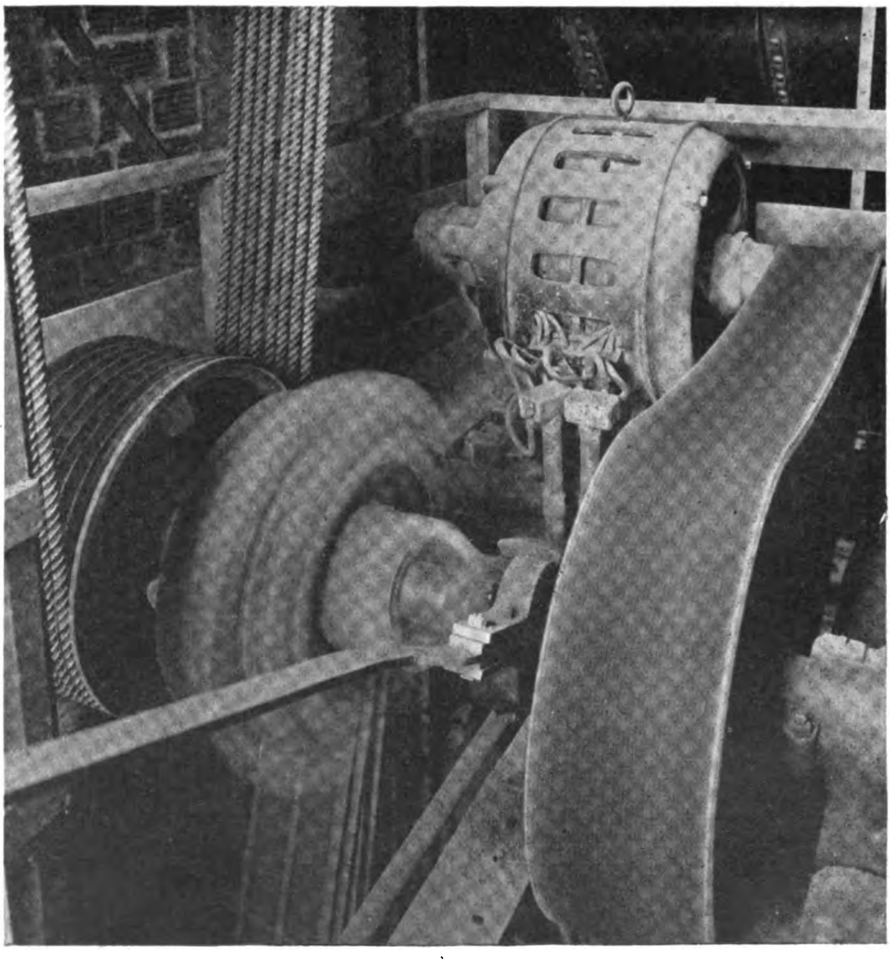
During the past five years or so a large amount of testing and research work on leather belting has been carried on by the Government and by the leather belting manufacturers, and much very valuable information has been obtained. Application of this information during the past year to the process of manufacture has brought about scientific control and a number of improvements in tanning and in some of the other operations involved. This has resulted in the production of belting which, it is claimed, is at least 25 per cent better than that which it has been possible to produce heretofore.

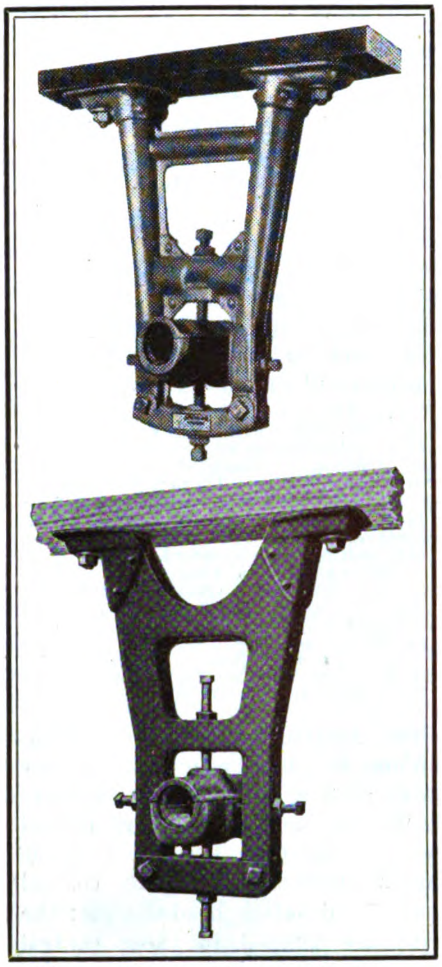
The selection, application and maintenance of belts, together with a description of the various types in industrial use, were discussed in the March, April, May and June, 1923, issues of INDUSTRIAL ENGINEER. The following companies have contributed much to the development and improvement of leather belting:

Acorn Leather & Belting Co., Detroit, Mich.; The Leather Belting Exchange, 119 S. Fourth St., Philadelphia, Pa.; The Chesapeake Belting Co., Baltimore, Md.; Chicago Belting Co., Chicago, Ill.; Detroit Oak Belting Co., Detroit, Mich.; The Graton & Knight Mfg. Co., Worcester, Mass.; Hide Leather & Belting Co., Indianapolis, Ind.; Jewell Belting Co., Hartford, Conn.; Laurence Belting Co., New York, N. Y.; Leather Kraft Co., Cleveland, Ohio; The Monarch Belting Co., Cleveland, Ohio; F. Raniville Co., Grand Rapids, Mich.; J. E. Rhoads & Sons, Wilmington, Del.; W. H. Salisbury & Co., Chicago, Ill.; Chas. A. Schieren Co., New York, N. Y.; The Taylor Belting Co., Indianapolis, Ind.; I. B. Williams & Sons, Dover, N. H.

The American Pulley Co., Philadelphia, Pa., has brought out a new design of steel split pulley. This pulley has six arms which are braced and set edge on. The rim is made like a channel iron, with central flanges and safety beaded rims; the arms are riveted to these central

A clutch saves power on this elevator drive by cutting out idle shafts and pulleys.





Above, this steel hanger is manufactured by the American Pulley Co., Philadelphia, Pa. Below, new design of steel hanger made by Dodge Manufacturing Corporation, Mishawaka, Ind.

flanges. The all-steel parting hub is clamped to the shaft with bolts.

A roller-bearing loose pulley, manufactured by the St. Louis Machine Tool Co., St. Louis, Mo., has recently been placed on the market. This pulley is equipped with a pair of adjustable, taper roller bearings and is made in any size from 2½ in. to 22 in. in diameter. In the small sizes the bearings are mounted directly on the shaft; in the larger sizes the bearings are mounted in a sleeve.

A pulley covering for reducing belt slippage has been brought out by the Monarch Belting Co., Cleveland, Ohio. This covering consists of treated duck which is cemented to the face of the pulley with a special cement. The covering is laid on in a single thickness, with a closely-fitting butt joint at the junction of the ends. It is claimed that it is unnecessary to use non-slip preparations on belts which run over pulleys faced with this fabric covering.

A description of the different types of pulleys, together with directions for ordering and installing them, was given in the November and December, 1922, issues of INDUSTRIAL ENGINEER.

Improvements in the design and manufacture of pulleys have been largely due to the work of these companies:

American Pulley Co., Philadelphia, Pa.; Birkle Machine Co., Chicago, Ill.; W. E. Caldwell Co., Louisville, Ky.; Chicago Pulley & Shafting Co., Chicago, Ill.; Cork Insert Co., Boston, Mass.; Dodge Manufacturing Corporation, Mishawaka, Ind.; W. A. Jones Foundry & Machine Co., Chicago, Ill.; Ohio Valley Pulley Works, Maysville, Ky.; Pyott Foundry Co., Chicago, Ill.; Reeves Pulley Co., Columbus, Ind., and Saginaw Manufacturing Co., Saginaw, Mich.

The American Pulley Co., Philadelphia, Pa., has also developed a new pressed steel hanger. The main frame is constructed of two stampings placed face to face with inturned flanges extending the entire length of the leg. The cross brace is integral with the legs. The feet are made of cold-drawn, seamless metal and are riveted to the legs. The hanger is of the parting type, with a swing yoke which greatly facilitates the work of putting up or taking down shafting, or installing or removing bearings.

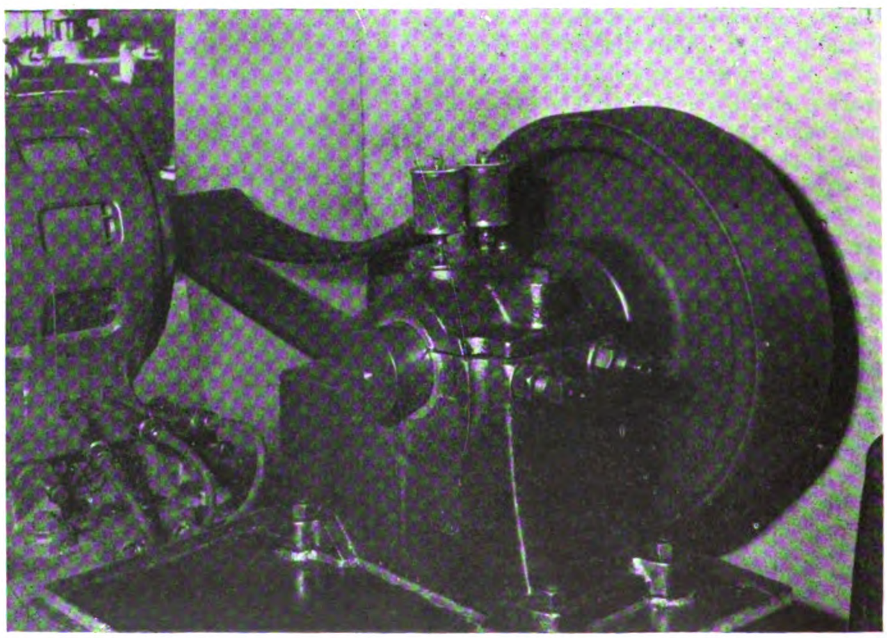
Dodge Manufacturing Corporation, Mishawaka, Ind., have recently made several important changes in the design and construction of their steel hanger. For example: A malleable-iron foot of ample proportions is now used and provides a broad, solid bearing. This casting projects downward a considerable distance on the frame, which adds a great deal to the rigidity of the hanger, and is securely riveted to the frame, which is of box construction welded and riveted together. Formerly the ring oiling bearing was the only type that could be furnished with this hanger. However, it is now possible to use the same type as formerly employed only rings for either ring or capillary oilers. This has been accomplished by a change in construction that permits the insertion of either rings or capillary blocks. The four-point adjustable feature provides for an ample range of adjustment.

Chain Drives

Silent chain drives have found a definite place in power transmission work, and in many cases this type of drive offers decided advantages. For example, silent chains are being widely used for individual drives for machines, particularly when the distance between driving and driven shafts is short. Chain drive is also being used between lineshafts or between lineshafts and countershafts when these are on short centers.

The Ramsey Chain Co., Inc., Albany, N. Y., has recently placed on the market a new design of silent chain, the chief feature of which is the compensating joint. There are two pins in each joint and the profile of the pins is such as to allow them

Chain drives are widely used where the distance between driving and driven shafts is short. Here a 100-hp. motor is driving a large fan.



to move toward each other, as the chain meshes with the sprocket, thus decreasing the effective pin diameter and increasing the pitch of the link to compensate for the accelerative impulse. This chain may, it is claimed, be run in either direction with equal facility and efficiency. A description of the various types of chains, with considerations governing their selection, application and care was given in the July, August and September, 1923, issues of INDUSTRIAL ENGINEER.

Companies which have been responsible for present developments in chain drives are:

American High Speed Chain Co., Indianapolis, Ind.; The Baldwin Chain & Manufacturing Co., Worcester, Mass.; Cullman Wheel Company, Chicago, Ill.; Diamond Chain & Manufacturing Co., Indianapolis, Ind.; Duckworth Chain & Manufacturing Co., Springfield, Mass.; The Jeffrey Manufacturing Co., Columbus, Ohio; Link-Belt Co., Chicago, Ill.; Morse Chain Co., Ithaca, N. Y.; The Whitney Manufacturing Co., Hartford, Conn.

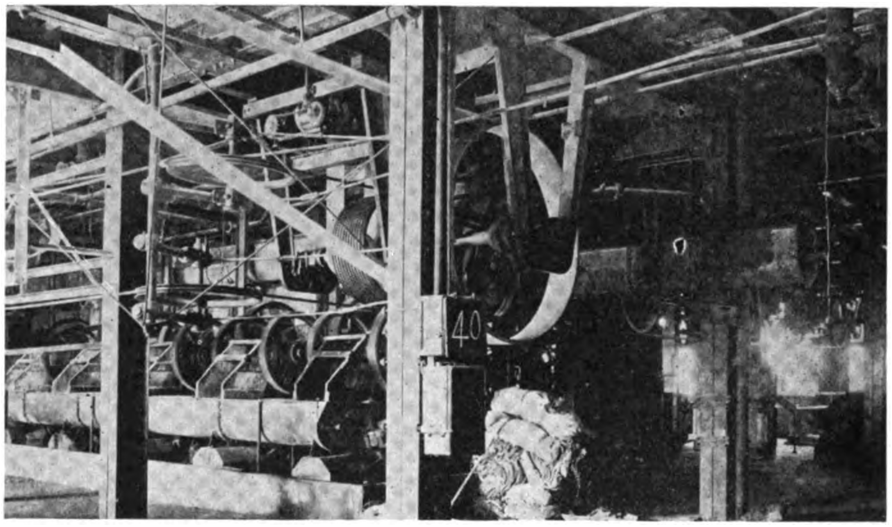
Clutches, Couplings and Speed Reducers

In new installations of power service equipment there is a growing tendency to use friction clutches more extensively than was formerly the case. These devices have been much improved during the past few years and this improvement has doubtless been an important factor in promoting their use. Realization by industrial engineers that a good deal of power can be wasted by running line- and countershafting idle has also contributed to a wider use of clutches and they are now being extensively used for disconnecting idle shafting and machines. In some new installations machines which do not have to be reversed or require changes in speed are being driven directly from the lineshaft by means of a friction clutch pulley. By this arrangement countershafts and belts are eliminated at a saving in power and maintenance charges as well as in first cost, with increased safety to the operator. Some machine tool manufacturers are now using a clutch on the driving pulley of their machines and eliminating the loose pulley.

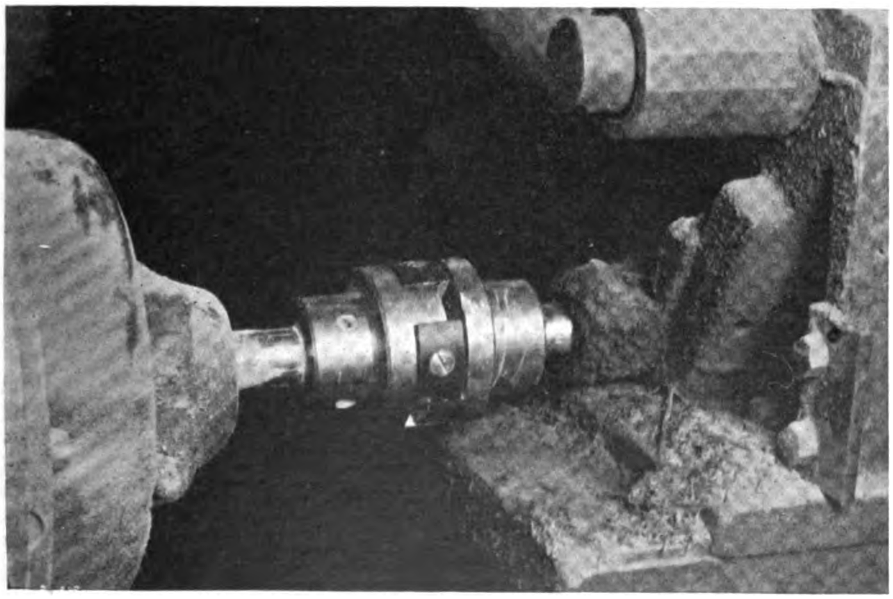
Among the new developments in this line of equipment is a multiple friction disk countershaft which is being marketed by the Warner & Swasey Co., Cleveland, Ohio. This countershaft is equipped with clutches having multiple friction disks, similar to the clutches employed in automobile construction. Hardened steel plates are employed in the clutch members.

The W. A. Jones Foundry and Machine Co., Chicago, Ill., has placed on the market the Lemley friction clutches and friction clutch pulleys. This clutch is of the well-known disk type. The friction disks are full floating loose fiber or burn-proof asbestos rings. One ring-nut adjusts all of the toggles, so that uniform pressure all around on the friction surface is assured.

When applied to pulleys the general design of the clutch is the same as for sleeve and coupling clutches, with the exception that provision is made for bolting the clutch to the pulley arms.



Belt, chain and rope drives operate side by side in this cement mill.



On direct drives a flexible coupling performs the important service of absorbing shocks, as well as transmitting power. The illustration shows the Higgins flexible coupling, manufactured by the Tomkins-Johnson Co., Jackson, Mich.

For a discussion of the various types of friction clutches and friction clutch pulleys, the reader should consult the article, Construction Details and Use of Clutches and Cutoff Couplings, in the January, 1924, issue of INDUSTRIAL ENGINEER.

Companies which have been active in the development of friction clutches are included below with those which have contributed to the development of couplings.

When the disadvantages connected with the old-time group drive, wherein all of the machine equipment was driven through lineshafting by one prime mover, were realized and individual drive was proposed, it was

hailed as a sort of cure-all for all operating troubles. The pendulum of opinion and practice then swung from one extreme to the other. Many engineers adopted the view that in place of driving all of the machines in a plant by one or two engines or motors, each machine should, whenever possible, have its own individual motor. Countless installations have been laid out on this basis.

More recently there has been a wider recognition of the fact that individual drive is not altogether free from undesirable features. The merits and disadvantages of individual drive and group drive will be thoroughly discussed in INDUSTRIAL ENGINEER in a series of articles, the first of which appears on page 56 of this issue.

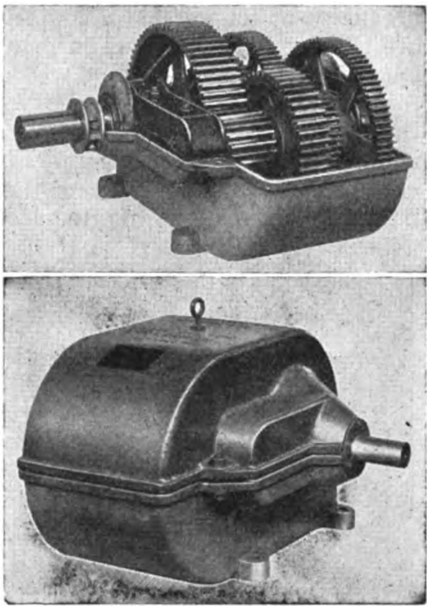
The tendency in recent installations has been to drive small groups of machines, preferably those which are turning out a similar product and can be operated as a unit, such as punch presses, automatic screw machines, and so on, from a single motor. If the individual machines are driven directly from the lineshaft through friction clutches or clutch pulleys, there can be obtained a drive which has most, if not all, of the advantages of individual drive, with few of its disadvantages.

When individual drive is used it is generally necessary to employ some form of flexible connection between the motor shaft and the shaft of the machine, in order to avoid shocks to and possible breakage of some of the moving parts. With the applications of direct drive to various kinds of machines, flexible couplings find an extensive field of usefulness. Several improved designs of flexible couplings have recently been placed on the market and deserve mention.

The Falk-Bibby coupling, manufactured by The Falk Corporation, Milwaukee, Wis., transmits power between two flanges by means of especially-constructed grid springs of tempered steel. True flexibility is obtained from the elastic properties of these springs, and the coupling is said to be capable of withstanding an unusual degree of parallel and angular misalignment of the shafts. The special feature of this coupling is, however, its torsional resiliency and consequent shock-absorbing properties obtained from the action of the springs, which engage with specially constructed grooves around the periphery of the flanges. These grooves fit the springs at the ends farthest apart, but flare towards each other.

The working parts of the coupling are enclosed in a floating shell which is packed with lubricant. The shafts can be aligned easily and can be disconnected in a few moments by simply releasing the shell and removing the springs around the periphery of the flanges.

Smith & Serrell, Newark, N. J., have developed and placed on the market a new fractional horsepower (1/4 hp. to 1 hp.) flexible coupling. This is a three-part, all-metal coupling, consisting of two similar flanges and a laminated spring cross.



Mill-type speed reducer developed by the Palmer-Bee Co., Detroit, Mich.

This spring cross fits into and connects the projecting parts of the flanges, so that the driving is done silently through the springs. This coupling is flexible in all directions, as well as extensible endwise.

This company has also recently put out a high-speed type of flexible coupling for turbine drives. This coupling consists of two similar forged steel flanges which are attached to the shaft ends in the usual manner. Between these flanges, and bolted to them, is the flexible member which carries on its periphery a number of projecting bundles of laminated steel springs. These spring bundles fit into movable slotted bushings or keepers in the outer member of the coupling. These keepers can rotate as well as slide endwise in this outer member and inasmuch as the bundle of springs can slide up or down in the keepers, flexibility of the coupling in all directions is obtained.

Charles H. Clark, New York, N. Y., has recently developed a flexible coupling which is claimed to combine strength, durability, flexibility and adaptability to a wide range of work. The hubs are finished all over and each has a triangular-shaped face which forms three projections or teeth. These teeth fit into and are enclosed by a housing made in three pieces, which serves to transmit the power from one hub to the other. The joints between the separate portions of the housing are secured by bolts fitted with locknuts and carrying leather washers at each end, to give flexibility. Further flexibility may be secured by inserting in each housing a piece of steel-faced automobile brake lining to cover the acting portion of the tooth.

The Tomkins-Johnson Co., Jackson, Mich., is also putting on the market a new flexible coupling, the Higgins. This consists of two flanged members, one of which is fastened to each shaft, and a third member which transmits the power between the other two members. Lugs on the shaft members fit into slots in the middle member in such a way that both angular and axial misalignment of the shafts is permissible.

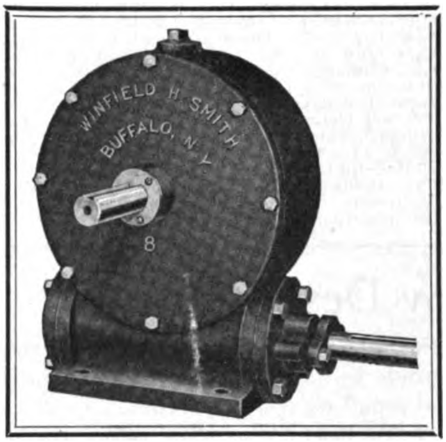
Descriptions of the various types of rigid and flexible couplings, with pointers on their selection and application, have been given in the October, November, and December, 1923, issues of INDUSTRIAL ENGINEER.

The following companies have been largely responsible for the development of friction clutches and rigid and flexible couplings:

Ajax Flexible Coupling Co., Westfield, N. Y.; Allis-Chalmers Mfg. Co., Milwaukee, Wis.; The Bartlett Hayward Co., Baltimore, Md.; Charles Bond Co., Philadelphia, Pa.; Bond Foundry & Machine Co., Manheim, Pa.; Brown Engineering Co., Reading, Pa.; The Carlyle Johnson Machine Co., Manchester, Conn.; Chicago Pulley & Shafting Co., Chicago, Ill.; Conway & Co., Cincinnati, Ohio; The Cutler-Hammer Mfg. Co., Milwaukee, Wis.; I. H. Dexter Co., Goshen, N. Y.; Dodge Manufacturing Corp., Mishawaka, Ind.; Falls Clutch & Machinery Co., Cuyahoga Falls, Ohio; The Falk Corporation, Milwaukee, Wis.; General Electric Co., Schenectady, N. Y.; The Hanson Clutch & Machinery Co., Tiffin, Ohio; The Hill Clutch Co., Cleveland, Ohio; The Hilliard Clutch & Machinery Co., Elmira, N. Y.; W. A. Jones Foundry & Machine Co., Chicago, Ill.; The Medart Co., St. Louis, Mo.; Mesta Machine Co., West Homestead, Pa.; The Moore & White Co., Philadelphia, Pa.; The Never-Slip Clutch Co., Noblesville, Ind.; R. D. Nuttall Co., Pittsburgh, Pa.; The Pusey & Jones Co., Wilmington, Del.; Reeves Pulley Co., Columbus, Ind.; R. H. & F. M. Roots Co., Connersville, Ind.; A. L. Schultz & Son, Chicago, Ill.; Smith & Serrell, Newark, N. J.; Thomas Flexible Coupling Co., Warren, Pa.; Weller Mfg. Co., Chicago, Ill.; Western Engineering & Mfg. Co., Chicago, Ill.; The Williams Foundry & Machine Co., Akron, Ohio; T. B. Wood's Sons Co., Chambersburg, Pa.

In many instances the speed at which the shaft of a machine should be driven is below a practicable motor speed. If it is desired to use direct drive, recourse must be had to some form of speed-reducing or variable-speed transmission device. New developments in speed-reducing devices include the Palmerbee mill type reducer, which has been put on the market by the Palmer-Bee Co., Detroit, Mich. This reducer is intended for use with conveying machinery, steel mill machinery, heavy shears, presses, and so on. Speed reduction is obtained through a train of spur gears, compounded to obtain the desired speed, and enclosed in a cast-iron housing. Wide face, coarse pitch gears are used, giving maximum strength and all shafts are supported by a bearing at each end.

An unusual design of variable-speed transmission has recently been developed by The Oilgear Co., Milwaukee, Wis. This consists essentially of a variable displacement pump which delivers oil to a constant displacement motor. When the stroke of the pump is set at a maximum it delivers a fixed quantity of oil to the motor and forces the latter to rotate at a speed equal to that of the pump. As the stroke of the pump is reduced the amount of oil pumped is decreased and the motor will rotate more slowly. Any desired speed of the motor shaft from zero to the full speed of its pump shaft may thus be obtained, merely by changing the stroke of the pump. Change of speed, as well as change of direction of rotation, is made by manipulating a control wheel. This variable speed transmission is provided with an automatic overload gear, which protects both it and the driven machine from damage due to overloads.



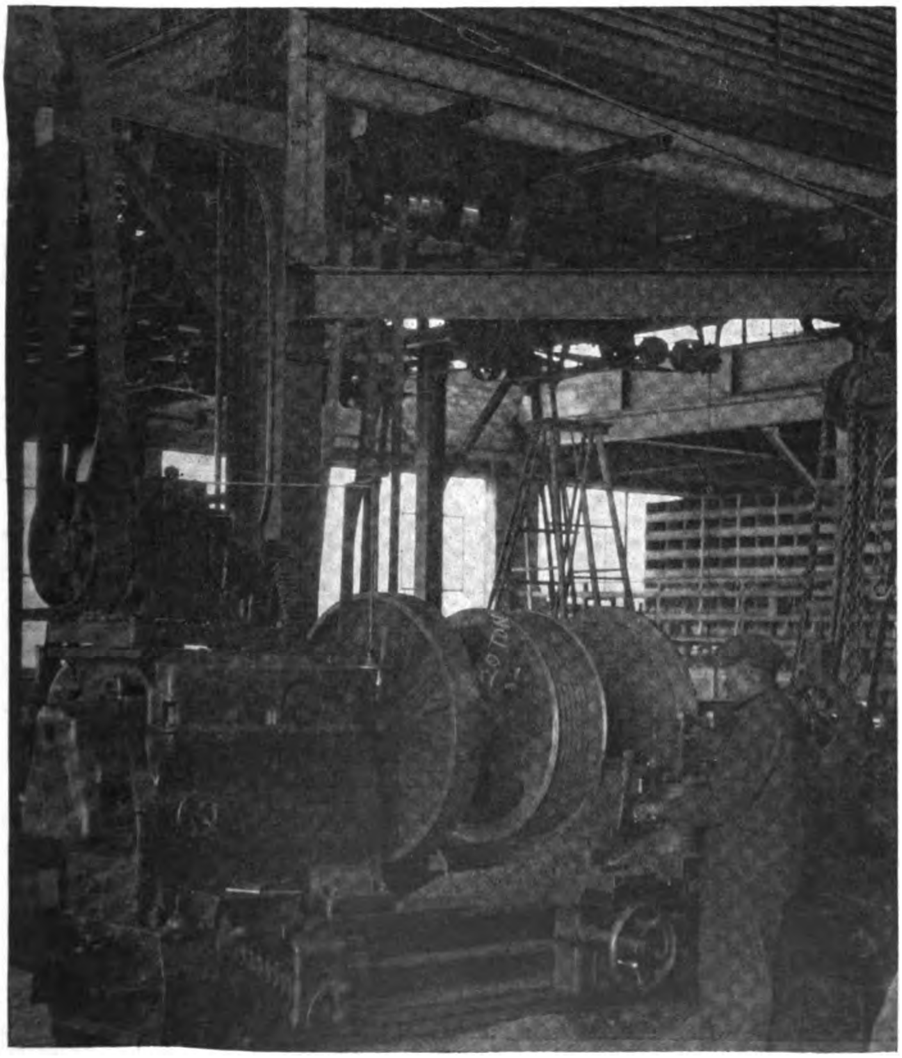
Small speed-reducing unit made by Winfield H. Smith, Buffalo, N. Y.

A speed-reduction gear in which the shafts are kept in line and which uses no toothed gears for ordinary speed ratios has recently been placed on the market by George Smith Morison, Pittsburgh, Pa. This gear has been built to give a reduction as high as 90,000 to 1 and can be made to give any ratio desired. In its simplest form this reduction gear consists of a high-speed shaft on which are mounted three or four plain cylindrical rollers, two of which are mounted in plates or disks which are in turn integral with the slow-speed shaft. Surrounding and enclosing the roller is a circular ring, which is in contact with the rollers on its inner face. When three rollers are used one is made larger than the others. This gives the ring an eccentric motion.

The central driving shaft is in contact with the rollers and when it rotates it causes them to roll around with it in the same direction and turn the slow-speed or driven shaft. For larger ratios of reduction than can be had with rollers alone a combination of the eccentric roller principle with epicyclic teeth gears is used. The outside face of the ring is turned to two diameters, with teeth cut in each face. The teeth of one of the faces of the ring is meshed into the teeth cut on the inside face of another ring surrounding it and fixed rigidly in the body of the casing.

Winfield H. Smith, Buffalo, N. Y., has recently placed on the market several new sizes of worm-gear speed reducing units. These units are capable of transmitting up to 3 hp. Some of the features of design are thrust ball bearings, large babbitt radial bearings on high-speed shaft, and stuffing boxes to prevent leakage of oil.

The calculation of gear trains, with a description of the different types of speed reducers on the market and their application, was given in the February and March, 1923, issues of INDUSTRIAL ENGINEER.



Speed control of this lathe for turning elevator shafts and drums is obtained by the use of the Oilgear variable-speed hydraulic power transmission, manufactured by The Oilgear Company, Milwaukee, Wis.

The following companies have contributed to the development of gears and speed-reducing devices:

Boston Gear Works, Norfolk Downs, Mass.; The Chicago Rawhide Mfg. Co., Chicago, Ill.; Christiana Machine Co., Christiana, Pa.; The Cleveland Worm Gear Co., Cleveland, O.; The Falk Corporation, Milwaukee, Wis.; Farrell Foundry & Machine Co., Buffalo, N. Y.; Fawcus Machine Co., Pittsburgh, Pa.; Foote Bros. Gear and Machine Co., Chicago, Ill.; William Ganschow Co., Chicago, Ill.; General Electric Co., Schenectady, N. Y.; The Horsburgh & Scott Co., Cleveland, O.; D. O. James Manufacturing Co., Chicago, Ill.; W. A. Jones Foundry & Machine Co., Chicago, Ill.; The Meachem Gear Corporation, Syracuse, N. Y.; New Process Gear Corporation, Syracuse, N. Y.; Niles-Bement-Pond Company, New York, N. Y.; R. D. Nuttall Co., Pittsburgh, Pa.; Philadelphia Gear Works, Philadelphia, Pa.; The Poole Engineering and Machine Co., Baltimore, Md.; Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Miscellaneous New Developments

Smith & Serrell, Newark, N. J., have recently put on the market the Keytite self-fitting key, for making the driving connection between shafts and couplings, pulleys, gears, and the like. These keys are made of a tough chisel stock and are ground to a size very slightly larger than the nominal keyway width. A cutting edge and chip recess are provided near the front end of the key. Ahead of these is a pilot slightly smaller than the nominal keyway width.

To install one of these keys the pilot is entered first with the cutting edge at the side. Then the key is driven home with an ordinary machinist's hammer or with a sledge, depending upon the size of the key. The cutting edge sizes the keyways to make a tight fit between the body of the key and the keyways. In the larger sizes cutting edges are sometimes provided on both sides and on top.

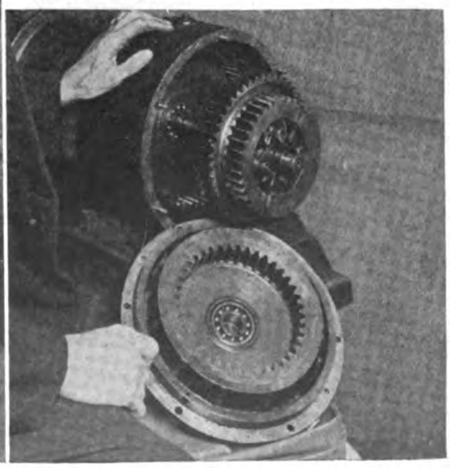
A new method of applying lubricating grease under high pressure to several bearings, through pipeline connections, has been developed by the Keystone Lubricating Company of Philadelphia, Pa. It is claimed that by this method of lubrication, bearings which otherwise would be difficult of access on account of small clearances between working parts, heat, and other unfavorable conditions can be reached easily. The device by which lubricating grease is delivered simultaneously to several bearings is known as the Keystone manifold safety lubricator. The lubricator, which is essentially a large cylinder into which is screwed a grease magazine fitted with a screw plunger, is of heavy, cast-iron construction. The magazine holds 8 lbs. of grease.

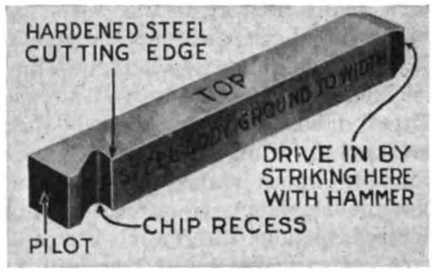
As a result of a recent change in the Underwriters' specifications which allows the use of single-stage centrifugal pumps for fire protection, the Allis-Chalmers Manufacturing Co., Milwaukee, Wis., has brought out a new single-stage pump. This pump is a modification of a special high-head type of single-stage pump which has been built for some years and meets the Underwriters' requirements.

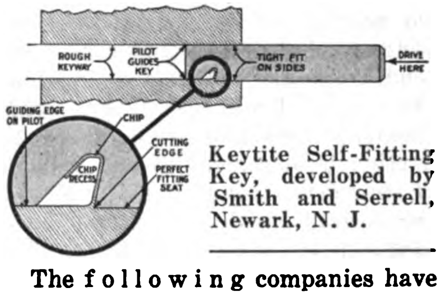
Types of fire pumps used with the Underwriters' requirements governing installation were described in the December, 1922, issue of INDUSTRIAL ENGINEER.

Speed reduction gear designed by George S. Morison, Pittsburgh, Pa.

This reducer uses rollers for low speed ratios as shown at the left. For high speed ratios an epicyclic gear train is used in combination with the rollers (right), as described more fully in the text on page 67.







Keytite Self-Fitting Key, developed by Smith and Serrell, Newark, N. J.

The following companies have played an important part in the development of pumps for fire and other service:

Allis-Chalmers Manufacturing Co., Milwaukee, Wis.; Buffalo Steam Pump Co., Buffalo, N. Y.; Dayton-Dowd Co., Quincy, Ill.; DeLaval Steam Turbine Co., Trenton, N. J.; The Goulds Manufacturing Co., Seneca Falls, N. Y.; Northern Fire Apparatus Co., Minneapolis, Minn.; Twinvolute Pump & Manufacturing Co., Inc., Newark, N. J.; Worthington Pump and Machinery Corporation, New York, N. Y.

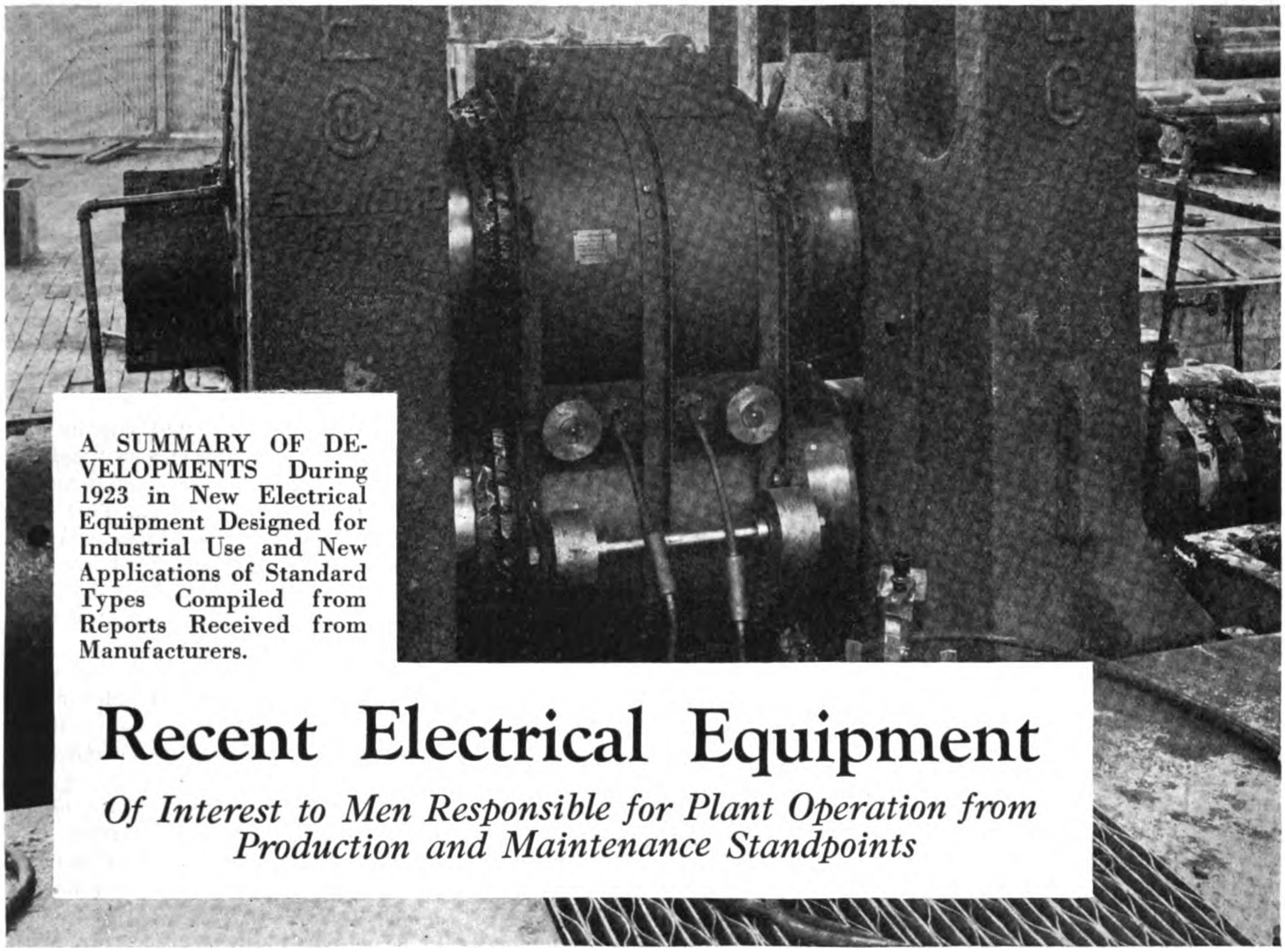
In addition to the developments mentioned above, several other companies have brought out new devices or improvements on existing equipment which are of interest to industrial engineers.

The Surty Manufacturing Co., Inc., Chicago, has put on the market an automatic and a semi-automatic cone belt shifter. This device eliminates the risks involved in shifting belts by hand and reduces the time required.

An outfit known as the Multiblaster has been brought out by George M. Stowe, Jr., Buffalo, N. Y. It is adapted for spray painting and sand blasting and for cleaning machinery and equipment in general with any solvent.

This outfit has been developed for all-around use in industrial plants. It is light in weight and portable, with a capacity limited only by the size of the container utilized for the liquids to be applied, or the size of the sand pile. The device is attached to air lines at any point near the work.

W. N. Matthews Corporation, St. Louis, Mo., is marketing mechanical painting units consisting of air compressor, electric motor, air reservoir and so on, mounted on a small truck for ready transportation to any desired location. These spray painting outfits can be made for gasoline-engine drive. (*Continued on page 101*)



A SUMMARY OF DEVELOPMENTS During 1923 in New Electrical Equipment Designed for Industrial Use and New Applications of Standard Types Compiled from Reports Received from Manufacturers.

Recent Electrical Equipment

Of Interest to Men Responsible for Plant Operation from Production and Maintenance Standpoints

Electric roll heater made by Freyn Brassert & Company, Chicago, Ill. This heater is used for preheating the finishing rolls of sheet and tin mills.

By ARTHUR J. WHITCOMB
Associate Editor, Industrial Engineer

THROUGHOUT 1923 electrical manufacturers have increased their volume of production in practically all classes of apparatus and in many cases the output has exceeded the maxima of war-time. High-pressure production is not usually conducive to radical changes in design and a considerable proportion of the improvements reported have been along conventional lines. There have been, however, a number of distinctive new developments which represented advances in the art. These took place not only in the industrial field but also in the transportation and public utility fields. It is the purpose of this article to summarize those of interest to the industrial user. Since this is a review of new applications of old equipment as well as recent developments in new equipment it will of necessity include machines and materials other than those developed only during the year 1923.

During the past year the Electric Power Club, which is an association of manufacturers of electric power apparatus and control equipment, has reprinted its handbook of standards and included all revisions and new additions up to October, 1923. These standards include new information on standard sizes of outlet or conduit terminal boxes for motors and standards for synchronous motors and new standards covering d. c. arc welding machines. Revised electric drill standards are given which are more severe than standards previously adopted. Details are included also on outdoor construction for single-phase and three-phase distribution and power transformers. Standard definitions are given for power switchboards and similar information for oil circuit breakers. The Electric Power Club during the year has also published rules for the installation, operation and care of motors and generators. These rules were published in the July and November issues of INDUSTRIAL ENGINEER.

Industrial Motors

Marked activity has been noticed in the development of industrial motors. This is not only along the lines of perfecting and rounding out lines of apparatus already developed, but in the design of new motors with better operating characteristics and higher efficiencies. Owing to the large number of motor applications in modern industrial plants, every detail of improvement in the operation or application of individual motors is of far-reaching economic value when considered in the aggregate.

Induction Motors.—The Wagner Electric Corporation of St. Louis, Mo., has developed a new motor known as the Fynn-Weichsel motor which combines the good characteristics of slip-ring induction and synchronous motors with most of

the undesirable ones eliminated. This motor is designed to operate at unity power factor—or when operated where induction motors are also used it can be adjusted to so compensate for the lagging current taken by the induction motors that practically unity power factor is obtained for the entire installation. In addition the makers point out that the Fynn-Weichsel motor develops a high starting torque with a starting current that is relatively low.

The stator and the rotor of this motor each have two windings. The rotor has slip-rings and a commutator. The commutator is used to obtain exciting current for one of the stator windings. The manufacturer claims that no commutator trouble is experienced, as the commutated voltage is very low—on the order of fifteen volts. It is also stated that the motor starts in a manner similar to a slip-ring induction motor, and as it approaches rated speed it pulls into synchronism and operates as a synchronous motor unless the load should exceed 150 per cent when it automatically reverts to slip-ring induction motor operation with about 3 per cent slip. If the load reduces again, the motor will automatically pull into step and operate at synchronous speed. These characteristics in a single motor represent a marked achievement in engineering design that should give this motor a wide application in industrial work.

The Reliance Electric and Engineering Company of Cleveland, Ohio, has put on the market a new squirrel-cage, polyphase induction motor known as type AA. The points featured in this motor by the manufacturer are the insulation of the stator windings, bearings, rotor construction and high overload torque capacity. It is pointed out that the stator punchings are assembled under ten tons pressure and then hot-riveted. The contraction of rivets in cooling aids in securing a tight and rigid core. The end flanges are ribbed to give greater strength and support to the stator laminations. The feet are cast integral with the flanges which are heavy and solid in order to reduce vibration and prevent loosening of feet from frame.

The stator coils are wound of cotton-covered enameled wire. The manufacturer states that the armature, after being wound, is treated and baked three times and then given a coat of air-drying varnish. The special insulation and the thorough dipping and baking, the maker points out, produces windings that resist the destructive influences of dirt, moisture, oil, acids, and alkalies.

The end ring of the rotor is of copper and is cast on to the extensions of the bars to provide a rugged construction.

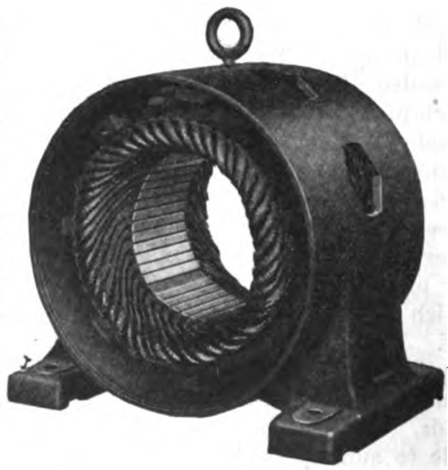
The Marble Card Electric Company, Gladstone, Mich., has brought out a line of alternating-current motors, in sizes up to 25 hp., which are equipped with ball bearings.

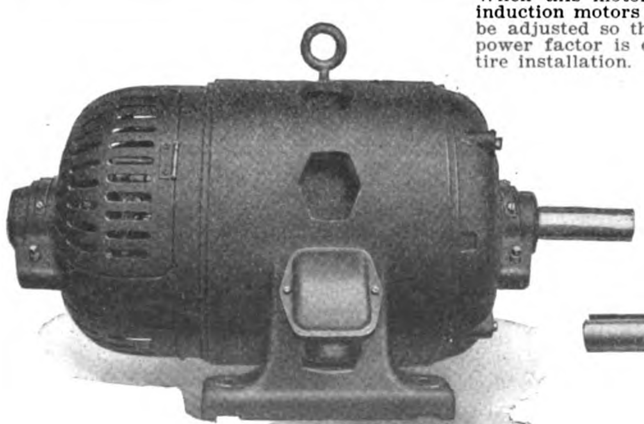
The Robbins & Myers Company of Springfield, Ohio, has put on the market a new polyphase, squirrel-cage motor known as type L. While these motors are smaller in size and lighter in weight than their predecessors, the type K line, it is claimed that nothing has been sacrificed in strength and rigidity and much has been accomplished in the way of improved performance.

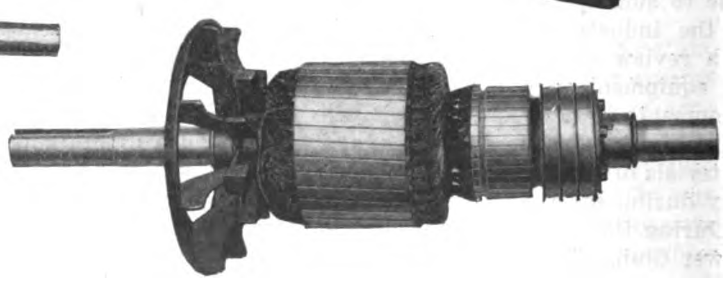
The General Electric Company has brought out a complete new line of 40-deg., continuous-duty, riveted-frame polyphase motors in sizes up to 15 hp. The maker states that this new line of motors embodies numerous improved electrical and mechanical characteristics as compared with previous construction of this class of motor.

The General Electric Company has also put on the market a new single-phase, repulsion-induction motor known as the type SCR. This motor is said to be of "balanced design"—a composite embodying the leading features most desirable in a motor without unduly accentuating any particular characteristic. The motor operates on the squirrel-cage, induction principle and eliminates entirely the short-circuiting switches heretofore considered essential. The maker further claims that the motor has a very high starting, accelerating and "pull out" torque, low starting current, practically perfect commutation, close speed regulation and high efficiency and power factor.

The Westinghouse Electric & Mfg. Company reports that its line of fractional horsepower type ARS repulsion motors has been completed and includes improvements which

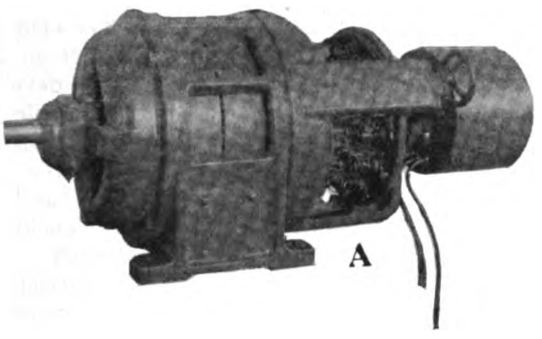




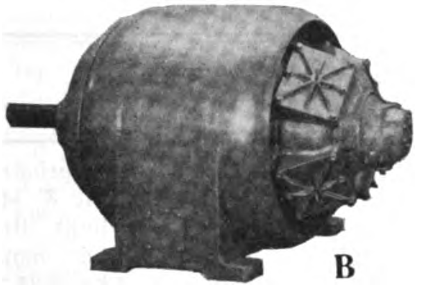


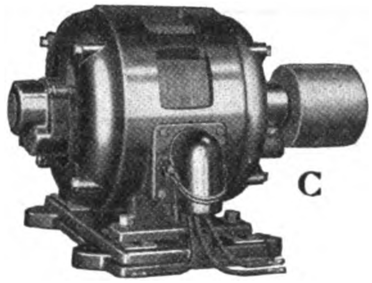
The new Fynn-Weichsel motor made by the Wagner Electric Corporation, St. Louis, Mo.

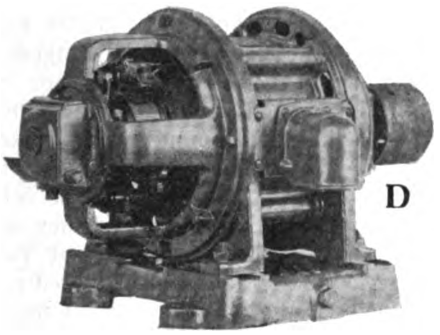
The stator is similar to that of an ordinary induction motor except that it has two windings. The rotor has slip rings and a commutator. The commutator is used to obtain exciting current for one of the stator windings. The motor starts similar to a slip ring induction motor, and then pulls into synchronism and operates as a synchronous motor. When this motor is operated where induction motors are also used it can be adjusted so that practically unity power factor is obtained for the entire installation.

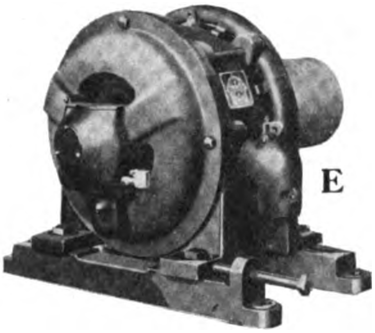


(A) is an a.c. adjustable-speed, brush-shifting motor made by the General Electric Company. (B) is a totally-enclosed induction motor developed for oil well service by the same company. (C) is a new polyphase induction motor made by Robbins & Myers Company of Springfield, Ohio. (D) is the new type SCR single-phase, repulsion-induction motor made by General Electric Company. (E) is the new type AA polyphase squirrel-cage induction motor made by Reliance Electric and Engineering Company of Cleveland, Ohio.









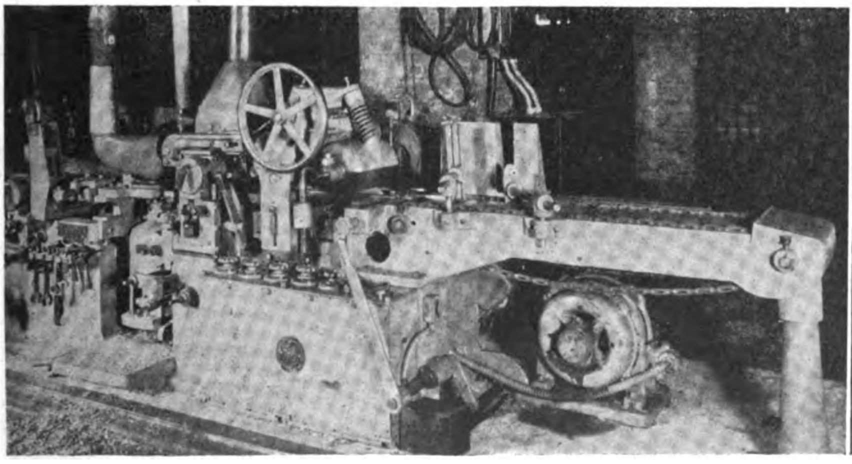
increase the operating life. This company further states that its line of single-speed and three-to-one speed squirrel-cage, elevator motors has been improved so that the motors are practically noiseless and have increased starting torque. A totally-enclosed, self-ventilated motor for fire pump service has been developed.

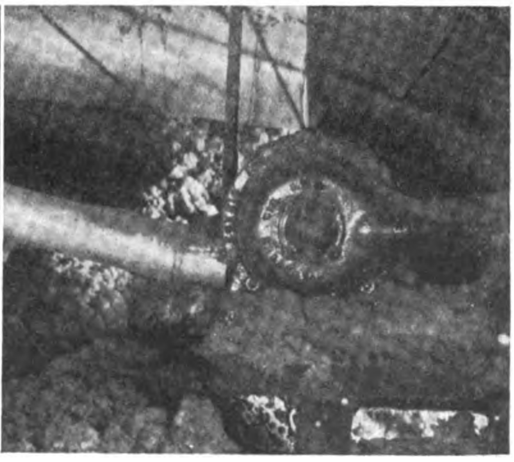
The American Electric Motors, Inc., of Milwaukee, Wis., is making a line of totally-enclosed, self-ventilated motors for which is claimed a great saving in maintenance expense where the motor is required to work in dirty locations. The motor is equipped with large ventilating fans attached to the shaft, which draw clean air through an inlet pipe from an outside location. The maker claims that the motor is drip-proof, dirt-proof, splash-proof and is built for use in foundries, flour and grist mills, woodworking plants, textile mills; in fact all places where motors are causing trouble from adverse atmospheric conditions.

The Triumph Electric Company, Cincinnati, Ohio, states that industrial plants can reduce maintenance and initial costs by the use of its self-starting, automatic, type TR motor. The TR rotor has a high-resistance winding which is used for starting but remains active as long as the stator is excited. There is also on the rotor a low-resistance winding which becomes active only after the rotor has reached a predetermined speed and at this speed is activated by the operation of a centrifugal governor. The maker claims that this motor, is different from the ordinary squirrel-cage motor in that the TR motor gives a very high starting torque with a limited starting current, that the compensator is eliminated, and that the motor is not disconnected from the line during the acceleration period. It is further pointed out that due to the high starting torque, these self-starting motors can generally be applied with a rating based on full-load conditions; consequently no necessity for overmotoring exists. Hence the maker claims that first costs are reduced because no compensator is required and no necessity for overmotoring exists, and that maintenance costs are re-

Applications of motors in industrial plants where much dirt is encountered.

At the left is shown a wood-moulding machine driven by five motors. A special, drum-type interlocking control is used which is provided with thermal overload protection. This application was made by General Electric Company. At the right is a totally-enclosed, self-ventilated motor made by American Electric Motors, Inc., of Milwaukee, Wis. Clean air is piped to this motor and the exhaust air leaves through another pipe, so as not to stir up the dust in the surrounding atmosphere.





duced because there is no compensator or other similar starting device to maintain.

The B. A. Wesche Electric Company, Cincinnati, Ohio, manufacturers of "Uniframe" motors in sizes from ¼ to 50 hp., state that the company has standardized on a line of ball bearings for use in its motors. This is in addition to its regular line of sleeve-bearing motors.

The Hertner Electric Company of Cleveland, Ohio, has recently brought out a line of polyphase motors in sizes ranging from ½ to 50 hp. This manufacturer claims that this motor has a practically indestructible rotor made with trapezoidal rotor bars brazed to recesses in cast copper end rings. The rotor is built so that the shaft can be easily replaced. The maker refers to the following features of the sleeve bearings used in this motor: two oil rings are provided in every bearing; oil guards are provided which force the oil rings to resume correct position on shaft; a symmetrical bushing is used so that it may be reversed and give longer life; a special design of oil well causes the dirt to gravitate to the drain hole; a semi-self-aligning mounting is used for the bushing.

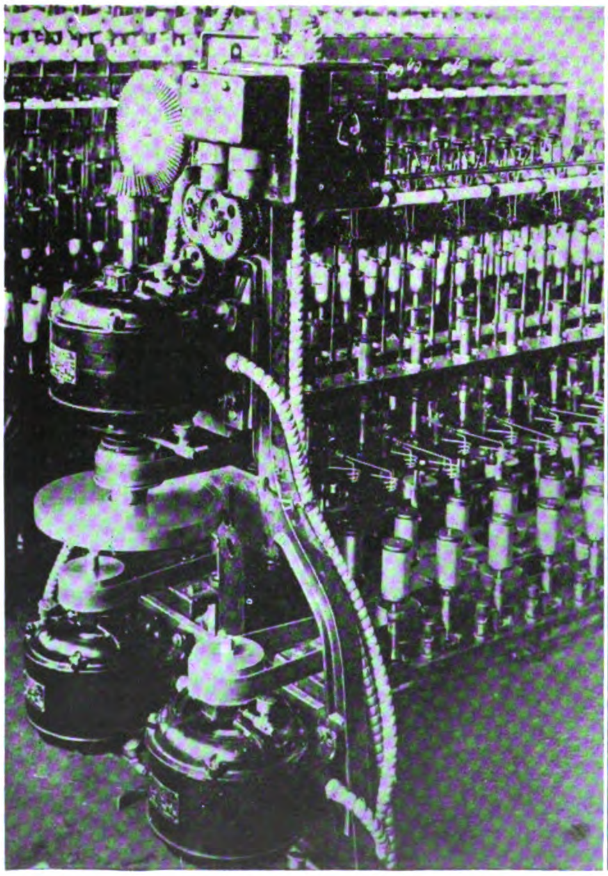
Synchronous Motors.—The Westinghouse Electric & Mfg. Company states that a new type of damper winding has been developed for high-speed synchronous motors, condensers and generators, which, in addition to simplifying the construction makes the machine capable of successfully withstanding much higher overspeeds than formerly. This manufacturer has built high-speed (650 hp., 3,600 r.p.m.) synchronous motors for driving multiple-stage, steam-turbine-type, air compressors. A 1,700 hp., 1,500 r.p.m. synchronous motor has also been built. The Westinghouse Electric & Mfg. Company has also extended the use of motor-driven gas compressors through the development of an enclosed type of collector to prevent the possibility of sparking at the brushes igniting the gas. The maker states that this has been accomplished by totally enclosing the rings in a sheet-steel drum through which air is forced by means of a separate, motor-driven blower.

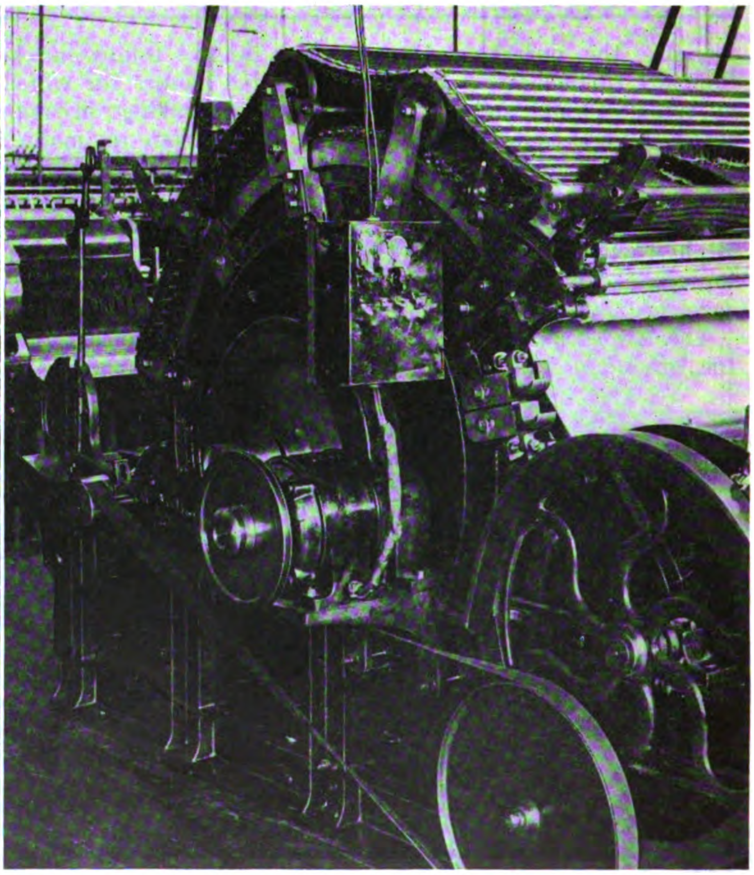
Industrial Motor Drives

Textile Motor Applications.—The Westinghouse Electric & Mfg. Company states that during the past year it has made successful applications of motors and control to card drives, silk spinners, and tandem finishing machine drives, which offer distinct advantages and improvement in the operation of the machines. Two new and typical installations are shown below.

Two new motor applications made by Westinghouse Electric & Mfg. Company of East Pittsburgh, Pa.
At the left is shown the application of three motors per frame to a silk spinner. At the right, the application of individual motor drive to a cotton card.

Steel Mill Motor Applications.—The Westinghouse Electric & Mfg. Company has recently built direct current, compound-wound motors rated at 240 volts, 1,500 hp., 125-250 r.p.m. and similar but larger motors rated at 1,800 hp., 165-350 r.p.m. These motors were used to drive the finishing stands of a 16-in. hot strip mill, each stand being driven by a separate compound-wound motor. The maker states that these motors are designed with such close inherent speed regulation that they operate throughout their speed range without any automatic, speed-regulating control. It is further pointed





out that this is the first installation of a drive for a continuous hot strip mill train which has been operated without special control for maintaining correct speed.

The General Electric Company has developed an alternating-current, brush-shifting motor with shunt characteristics. This company states that this motor, without auxiliary apparatus, gives adjustable speed that is practically independent of load. Machines of this type that are rated at 600/400/200 hp. 321/214/107 r.p.m., 25 cycles and 500/385/250 hp., 130/100/65 r.p.m., for the same power supply have recently been built for driving merchant mills. The General Electric Company states that the tendency towards the use of high-speed motors with reduction gears, which has been quite marked for the past few years, continues to gain headway and that over 90 per cent of the new motors for main roll drives are for geared service.

The Westinghouse Electric & Mfg. Company reports that orders have been received for five large main roll drives which are to replace the present steam drives. One of these drives consists of a 1,500-hp., 230-volt, 470-510-r.p.m. direct-current motor, a 1,000-kw. synchronous motor-generator set, a 75-hp. reel drive, and complete control. This set will replace the engine drive on the finishing stands of a rod mill. The roughing and intermediate stands of the mill are to be driven by the present engines, the speeds of which are subject to considerable fluctuation. It is pointed out that the automatic control which will be supplied for the 1,500-hp. motor will cause it to follow the variations in the speed of the engines, thus preventing breakage of the hot steel rod or damage due to excessive looping. Automatic control is also included for the rod reel drive which the maker says will allow the reels to take up the finished rod uniformly, regardless of the speed of the mill.

Paper Mill Motor Applications.—The Westinghouse Electric & Mfg. Company has installed and placed in operation during the year a sectional paper machine drive on one of the world's fastest paper machines, the paper speed being 1,200 ft. per minute. The motor equipment for this installation is rated at 50 to 150 hp., 265 to 700 r.p.m. This company has also built a 90 to 92-hp., 100-1,100-r.p.m motor which is the largest speed-range motor it has built for single-motor, paper-machine drive.

Oil Well Motor Applications.—It is essential that a motor for oil-well pumping be capable of meeting the widely different operating requirements of pumping, pulling and cleaning the wells and yet function efficiently when employed under these same conditions of operation. To meet these special requirements the Westinghouse Electric & Mfg. Company has developed a 35/15-hp., type CW two-speed, wound-rotor induction motor for three-phase, 440-volt, 50- or 60-cycle operation. Two of these motors are combined in the two-motor, oil-well drilling equipment which the Westinghouse Company says has been tried out with great success in the Mid-Continent oil fields.

The following advantages are claimed for this equipment:

1. A perfect drilling motion at all depths of hole.
2. Greater reserve power than available with steam engines.
3. Reduction of idle equipment at close of drilling program, since the same motors are used for both pumping and drilling.

To meet the requirements of the Russian Government in regard to electrical equipment for oil-well drilling, the General Electric Company has developed two totally-enclosed induction motors, rated at 75 hp. and 50 hp., 750 r.p.m. This company further states that these are the largest totally-enclosed, self-ventilated motors yet made; previous designs in these sizes employed water as a cooling agent.

Woodworking Motor Applications.—Several manufacturers of sawmill and woodworking machinery have designed new planers and matchers on which the motors are direct connected to the various spindles. The Westinghouse Electric & Mfg. Company states that it is supplying shaftless motors and controllers for this class of equipment. It is also mentioned that in all cases two motors are being used on the top planer head in order to obtain the necessary power without increasing the diameter of the motor. The Westinghouse Company is making shaftless induction motors as large as 30 hp. at 3,600 r.p.m. for this class of equipment. By the use of a small frequency changer for converting the 60-cycle supply to 120 cycles, a motor speed of 7,200 r.p.m. is obtained, which gives even greater production on a matcher or woodworking machine of that description.

During the year considerable work was done towards standardizing the bores of these small, shaftless motors. Through the efforts of several of the electrical companies, most of the tool manufacturers are now using a definite bore for the insertion of the shaft.

The DeWalt Manufacturing Company of Leola, Lancaster, Pa., has developed a "Dew-All" bench machine for handling a wide range of woodworking jobs. This machine has a motor mounted from an overhead swinging arm, so arranged that it can be swung into any desired position over the work bench. On one end of the motor shaft is a pulley and on the other is a clamp for attaching a circular saw that will do cross cutting, ripping, mitering, bevelling, matching, moulding, irregular shaping, dadoing, routing, sanding, boring, turning, fluting, tenoning, boring or panel raising on any rake or bevel.

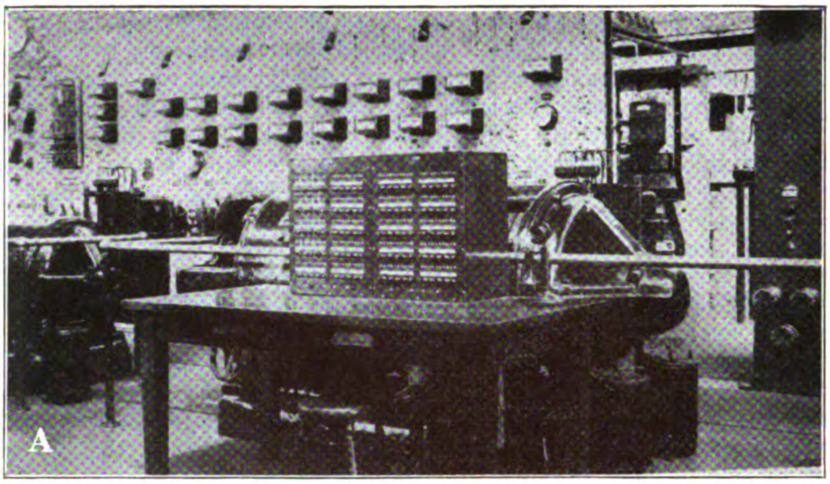
Electric Control Equipment

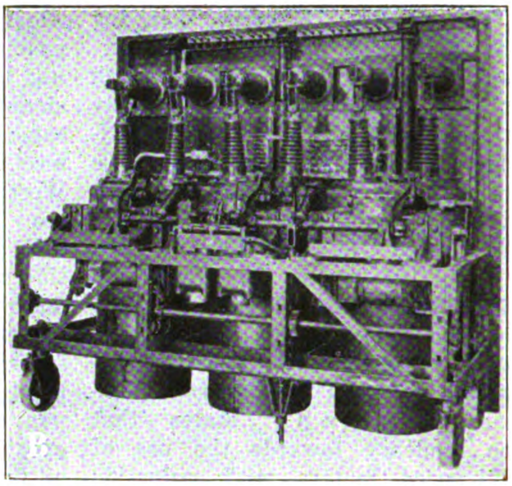
Motor Control.—The Westinghouse Electric & Mfg. Company reports that it has perfected an automatic synchronous motor control with dynamic braking that is obtained in a manner comparable to that used on direct-current motors and brings the motor to a quick but easy stop without shocks. This control, it is claimed, is particularly adapted for use on rubber mill motors which are often required to make a quick stop in an emergency. Reference is made to an installation of two 250-hp., 600-r.p.m., 2,200-volt, 60-cycle synchronous motors complete with this automatic control; in dropping from 600 r.p.m. to 0 r.p.m, the motors make only a little over two revolutions. The maker further states that this method of braking is more accurate than mechanical brakes and imposes smaller mechanical stresses on the machinery.

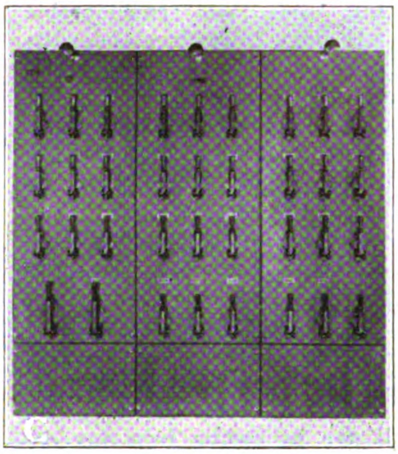
The Westinghouse Electric & Mfg. Company has also developed an alternating-current plugging control for a two-motor calendar drive. This

Typical Items of Industrial Control Equipment

Devised to Handle a Variety of Service Requirements







A—Supervisory equipment built by General Electric Co. for controlling feeders and apparatus at a distant substation.

B—Type FK-130 truck-mounted oil circuit breaker made by General Electric Co.

C—Front view of "Bull Dog" safety type industrial switchboard made by the Mutual Electric & Machine Co., Detroit, Mich.

D—Rear view of the same switchboard.

E—A 2,200-volt air-break, alternating-current magnetic contactor manufactured by Westinghouse Electric & Mfg. Co.

F—The new enclosed, self-ventilated motor for fire pump service built by the Westinghouse Electric & Mfg. Co.

G—Thermal relay type TR designed by the Automatic Reclosing Circuit Breaker Co., Columbus, Ohio.

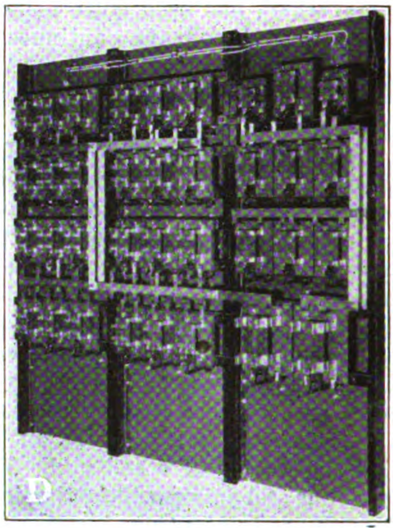
H—I-T-E synchronism actuated lock-out relay made by The Cutter Co., Philadelphia, Pa.

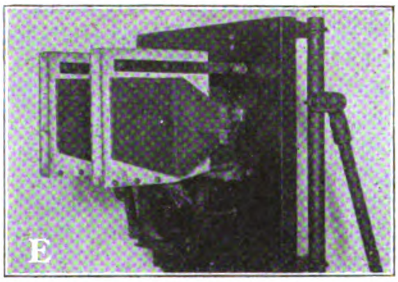
I—Type AF automatic auto-starter made by Westinghouse Electric & Mfg. Co.

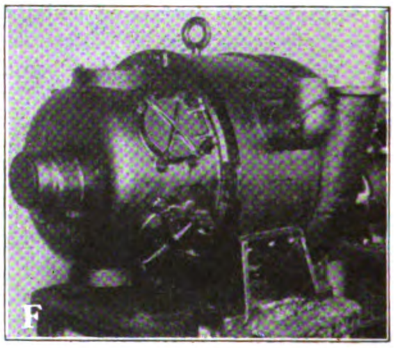
J—Type ZK manual-automatic compensator made by The Electric Controller & Mfg. Co., Cleveland, Ohio.

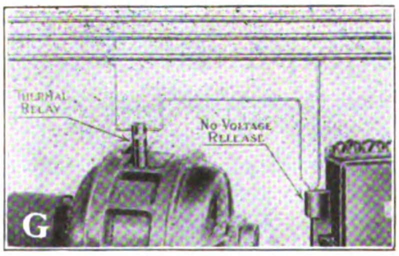
K—Primary-resistance, hand starter manufactured by General Electric Co.

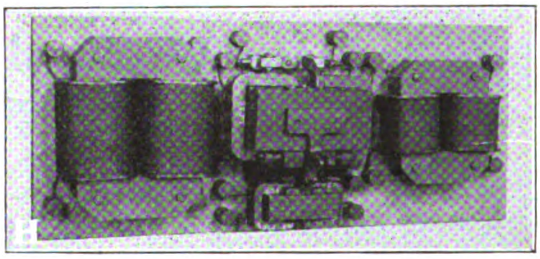
L—Automatic substation equipment installed underground in salt mine for controlling a synchronous motor-generator set. This equipment was made by General Electric Co.

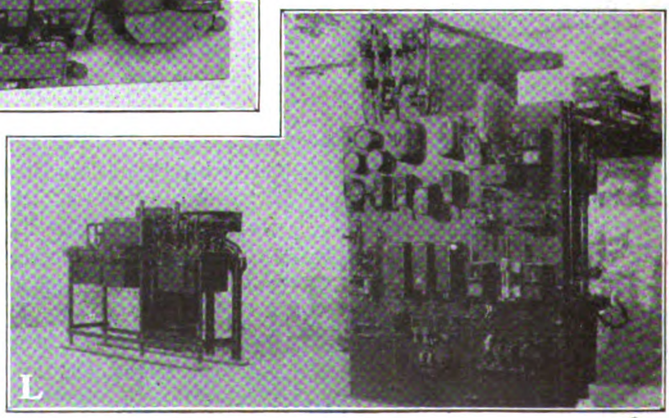


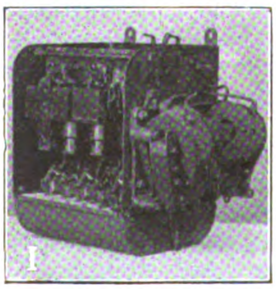


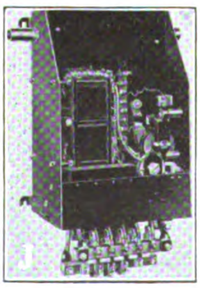


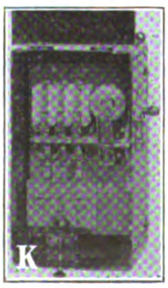


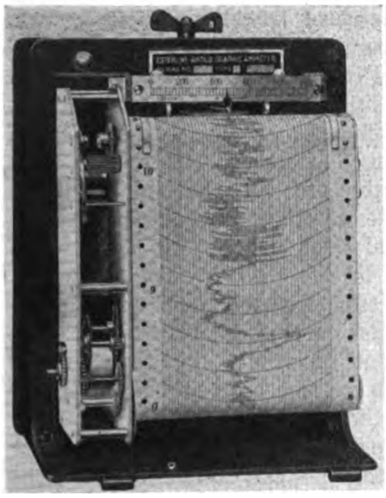


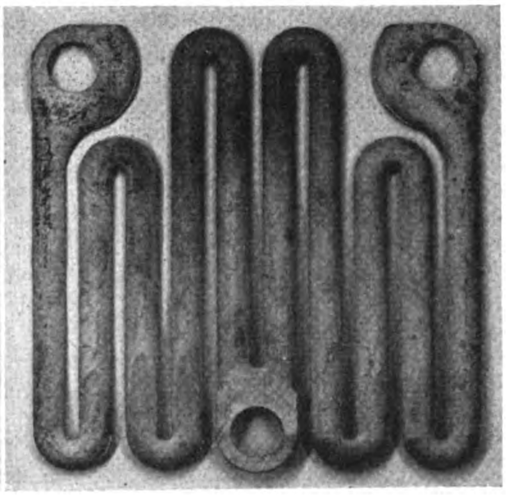












Two products of interest to the maintenance department.

On the right is a punched steel resistor grid made by the Westinghouse Electric & Mfg. Company of East Pittsburgh, Pa. The graphic meter is made by the Esterline-Angus Company of Indianapolis, Ind. Instead of the usual clock drive for the chart, this meter is equipped with an electrically-operated drive by which any number of meters may be operated in synchronism with a master clock.

company has standardized its large printing control equipments. It has developed an alternating- and direct-current universal printing control, a five-pole, alternating-current contactor, a 2,200-volt, air-break, alternating-current magnetic contactor, and a new line of across-the-line starters for small squirrel-cage motors.

The Electric Controller & Mfg. Company of Cleveland, Ohio, has developed a new type ZK manual-automatic compensator. It is pointed out that this compensator disposes of the objectionable features of the so-called "hand compensator" and at the same time has all the good points, with the exception of remote control, of the automatic compensator. With the type ZK compensator it is necessary to throw the handle only to the starting position. The maker states that after the motor has accelerated to a speed where it can be safely thrown across the line, a relay operates a mechanism which automatically throws the compensator from the starting position to the running position. This compensator is equipped with inverse-time-element overload protection obtained by means of an expansion wire overload device which the maker claims protects against overload or excessive load due to single-phase operation of the motor.

The Westinghouse Electric & Mfg. Company has developed a type AF automatic auto-starter, arranged for push-button control. The maker claims that this automatic compensator accelerates the motor correctly, because definite time acceleration is employed.

A new enclosed automatic starter, the CR-7056-D1, of the primary-resistance type, has been developed by the General Electric Company for starting polyphase squirrel-cage induction motors under light load. The resistance of this starter is proportioned to give an inrush current of 3½ times the normal full-load motor current, permitting the motors to develop at least 50 per cent full load torque in starting. These starters are equipped with a single-step resistor, equal parts of which are connected in each phase. The switching elements consist of a starting contactor, a running contactor and a time-limit accelerating relay whose action is retarded by an alternating-current magnetic drag. Overload protection is provided by a thermal overload relay. The starter is of the safety type, completely enclosed with a ventilated case. The time interval of the closing of the accelerating relay can be changed from approximately three to eight seconds.

The Condit Electrical Mfg. Company of South Boston, Mass., has designed a thermal relay for use on its recently developed type N-4 motor starter. The thermal relay is made up somewhat similar in form to a fuse cartridge. This relay consists of a heat element around which is spirally wound a bimetallic strip. This strip is arranged to either open or close a contact when the heat element becomes hot enough to cause the spiral to unwind. The relay contacts are in series with either the undervoltage or shunt trip attachment and hence in case of overload will trip the motor free from the line. After an overload the relays automatically reset to the normal operating position.

The Automatic Reclosing Circuit Breaker Company of Columbus, Ohio, has also developed a thermal relay designated as type TR. This relay is designed to be universally applicable to any surface, including motors, small shaft bearings, station transformers, etc., from the temperature of which it may be desired to operate a relay. The bottom of the relay is fitted with a brass bulb in which is a sylphon element. When the temperature of the surface with which the brass bulb is in contact exceeds the temperature at which the relay is rated, the sylphon element expands and operates a push-button switch at the end of the relay. The standard relay is built to operate at 75 deg. C. The manufacturer states that the relay was designed to be placed on that part of the motor frame or stator laminations the temperature of which indicates the degree of heating to which an overload may subject the motor.

To assist in the standardization of resistor grids the General Electric Company has developed a type BG railway resistor which is interchangeable, both electrically and mechanically, with other resistors on the market. The unit consists of a sheet-steel punched end frame with sufficient holes to make possible its support on the same bolt hole centers as other generally used resistors. The convolutions of this new type resistor are said to be shorter than the General Electric CG and RG types; the grids are stronger and less likely to break or warp and the number of contacts is reduced to half.

The Westinghouse Electric & Mfg. Company has also completed a new line of punched steel grids for resistors. The maker claims that this type of grid is free from breakage and is economical in space. The Ward-Leonard Electric Company of Mt. Vernon, New York, has just put into production a fully-enclosed type embedded resistor for speed regulation duty.

For use where vibration and jars are likely to loosen the resistor from a standard screw socket, the Ward-Leonard Electric Company has developed a Vitrohm resistor unit with Edi-swan (bayonet lock) base. This resistor unit is made for reducing regular line voltage to meet the re-

quirements of so called "low-voltage" devices, used on motor-generator sets, industrial control, etc.

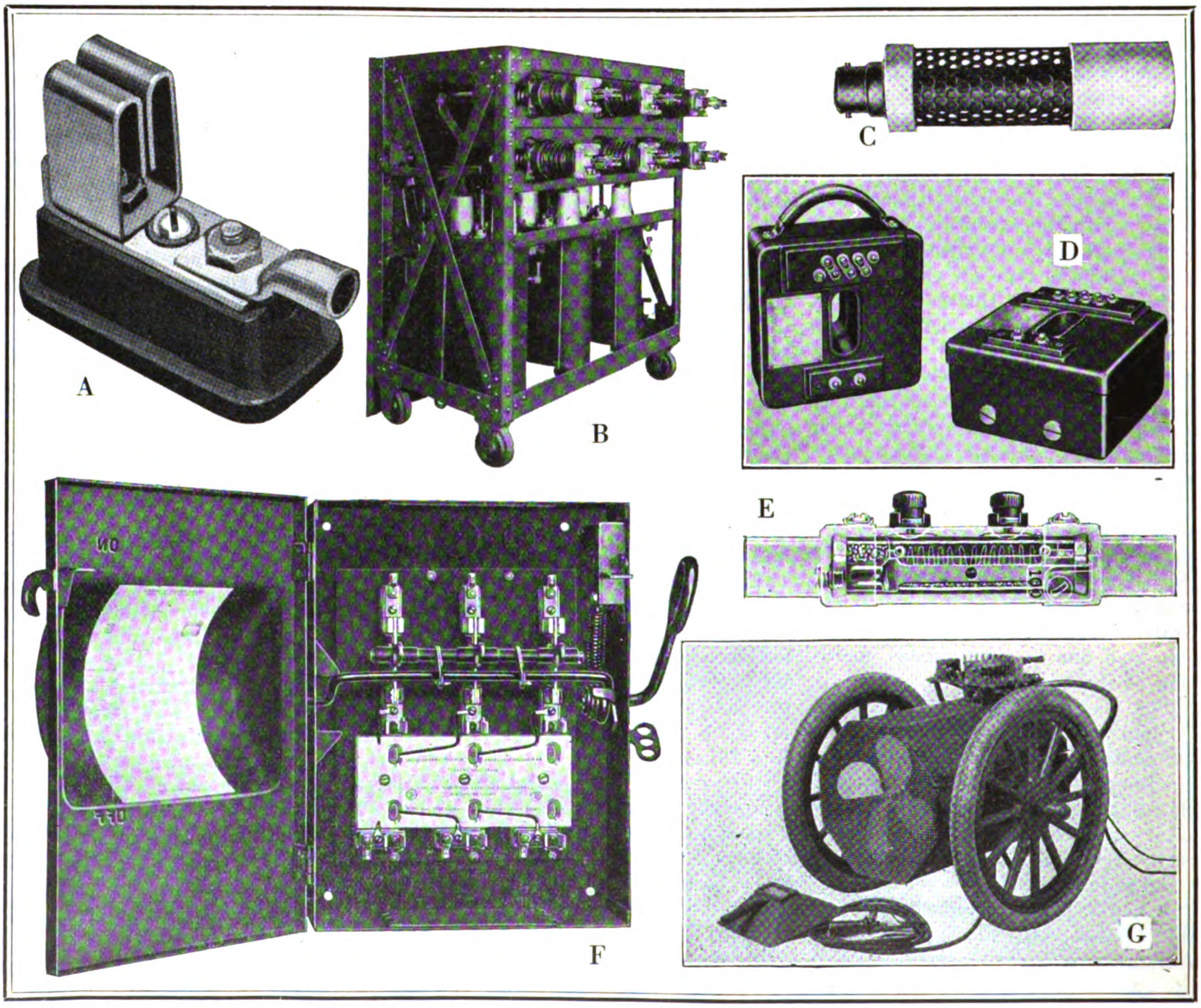
For the protection of three-phase motors against the evil effects of single-phase operation, the Westinghouse Electric & Mfg. Company has developed a negative-phase balance relay for the protection of all the essential auxiliary motors. The maker states that this relay is entirely new and so sensitive to single-phase operation that an unbalance of 10 per cent will create enough single-phase effect to trip the breaker.

The Federal Electric Company, Chicago, Ill., has recently developed a special type of back connecting block which fits in the unit type "Square D" line of switches. This block fits in between the fuse jaws on the switch. The block carries the back contacts and auxiliary wiring required for the use of the "Federal National Multiphase" time-limit, powder-packed fuse. The advantages claimed by the manufacturer for this fuse are: (1) Prevents single phase operation of motors. (2) A definite time delay before fuse will blow. (3) Fuse can be refilled with renewal element. (4) Fuse operates at lower temperature resulting from less potential drop over fuse and consequently fuse has very low power loss.

Recently developed products of interest to men in charge of maintenance in industrial plants.

(A) The unit base of moulded composition used in the Square D Switch shown at F. (B) Truck type circuit breaker made by Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. (C) "Vitrohm" tube resistor with bayonet lock base. Made by Ward-Leonard Electric Company, Mt. Vernon, N. Y. (D) Portable current transformer with range from 0 to 800 amp. Made by Esterline Angus Co., Indianapolis, Ind. (E) Fuse which protects motor from overloads or single phase operation. Made by Federal Electric Company, Chicago, Ill. (F) Safety switch with the unit type bases shown at A. Made by Square D Company, Detroit, Mich. The block shown between the fuse clips is the back connecting block made by the Federal Electric Company for use with its Multiphase fuse shown at E. (G) Portable arc welding generator made by the Liteweld Co., Cleveland, Ohio.

The fuse is composed of a fuse link and a heating element, both enclosed in a powder-packed tube. The fuse link terminals are brought out on the ends of the tube while the heating element terminals are brought out on the sides. These side terminals make contact with the special back connecting block when used in the new Square D switch. This tube with elements goes inside the fuse cartridge where the heating element terminals engage with terminals on the side of the cartridge and the fuse link is connected to the fuse terminals at the ends of the cartridge. The terminals of the heating element are connected to the fuse terminals of the adjacent fuse so that the heating element is in parallel with the adjacent fuse. When the adjacent fuse is blown the open phase voltage across the blown fuse is impressed on the heat element of the first fuse. The heat element melts the fuse and then melts itself, thus making two breaks in the cir-



cuit and shutting down the motor. Likewise the remaining fuse is blown, if the motor is three-phase.

Safety Switches.—The Square D Company of Detroit, Mich., has recently brought out a safety switch known as the 80,000 series, in which several new features are incorporated. The switch has unit bases of moulded composition for each jaw and fuse clip, instead of the old slate base. The maker claims that this does away with base breakage and metallic veins and also permits removal of parts from the front of the switch in a few minutes' time. The manufacturer also states that the Square D cover control makes it impossible to open the box cover while the switch is closed and prevents operation of the switch when the cover is open. A key permits authorized persons to do both these things, allowing for competent inspection under load.

The Super-Safety Switch Company of Chicago, Ill., reports that it is increasing its line of switches to include sizes up to 200 amp., 600 volts. Until the present time the "Super-Safety" switch has been built only in the 30-amp. size.

The Mutual Electric & Machine Company, Detroit, Mich., has made some recent large installations of its model WF-5, dead front, industrial-type switchboards. On these switchboards the operating levers are mounted on the front of the board and means are provided for locking them on or off with ordinary padlocks. The switches with connecting busbars are mounted on the rear of the board, ample wiring room being provided between the switches and the board. All parts are removable units which permit of repairs or replacements without interfering with other apparatus on the switchboard. Fuses and parts holding the fuses are disconnected and "dead" when the switch is open.

The Westinghouse Electric & Mfg. Company has developed an enclosed-type safety switch in which special provisions have been made for extinguishing the arc. It is pointed out that this feature has been found to be very effective both on direct current and alternating current. A new safety motor starting switch that also has the arc extinguishing feature is made by Trumbull Electric Mfg. Company, Plainville, Conn. The maker points out that this switch has protection against single-phase operation of the motor.

The Miniature Breaker Company, Inc., of Long Island City, N. Y., has recently developed a line of "Minibreakers" that are a circuit breaker and motor starter combined and are for use on small polyphase motors the full load current of which is 20 amp. or less. The maker claims that the "Minibreaker" gives very small motors protection against overloads and single phasing which cannot be readily obtained from fuses.

The Trico Fuse Mfg. Company of Milwaukee, Wis., calls attention to the economies that can be obtained through the use of Trico fuses because it is impossible to double up the renewal links, thus permitting overloads to the circuit and also damage to the fuse through overloading.

Substation Equipment

The Westinghouse Electric & Mfg. Company has made interesting improvements and developments in substation equipment among which are the following: the addition of high reluctance poles to 60-cycle synchronous converters; improvement in design and reliability of static condensers; use of the "Inertaire" transformer, in which an inert gas is introduced above the oil level to protect the oil against oxidation and reduce fire and oil explosion risks; improvement of the manner of making transformer tap changes; the development of supervisory control or machine switching, by which a single operator in a central location may have complete control information concerning the operating status of an entire generating and distribution system.

The General Electric Company reports the development of a new induction voltage regulator.

Both companies report an increased use of truck type switches and the rapid extension of automatic substations to coal mining and industrial fields.

Meters and Relays.—The Esterline-Angus Company, Indianapolis, Ind., has brought out a new line of graphic instruments known as type LR. The maker points out the following new features of these meters: A removable ink well to facilitate filling and cleaning; a pen element that can be removed quickly without the aid of tools; the entire back of the case can easily be removed without breaking any electrical connections.

The meters can be furnished with either spring-operated or electrically-operated clocks. The electrically-operated clocks are made to operate in connection with standard, impulse-type timekeeping systems. Where a number of instruments are installed, a master contact-making clock can be used to control all of the instruments, and where an electrical time system is already installed, the instruments can be connected to this system. In this type of clock the escapement and springs driving it are omitted and replaced by an electromagnet, actuated by impulses of current from the controlling system, which drives the chart moving mechanism.

The Esterline-Angus Company states that the national Bureau of Standards has recently made some interesting tests on the Esterline-Angus portable universal transformer which has six primary combinations giving a range from 0 to 800 amp. This company has also developed a wind velocity meter which measures the instantaneous velocity in miles per hour. The meter is made in the indicating or recording types and finds application on coal or ore bridges where it is desirable to know the velocity of the wind so that operations may be stopped and the bridge clamped to the rails when the wind velocity becomes dangerously high.

During 1923 the Weston Electrical Instrument Company., Newark, N. J., placed on the market a group of portable a.c. testing instruments which are known as the Weston Junior group. They consist of shielded movements enclosed in bakelite cases. This group has, in addition to its unusual portability, the very advantageous feature that it is possible, by means of two portable transformers, the model 461 current transformer and model 457 potential transformer, to obtain readings covering a range from practically 0 to 2,200 volts and 800 amp.

The Westinghouse Electric & Mfg. Company has developed an entirely new line of a.c. switchboard instruments working on the dynamometer principle and replacing the former

well-known Westinghouse induction type. These new instruments contain many novel and interesting features. In addition to the usual 7-in. type, these are made as a complete line in a smaller case 4⅜ in. in diameter, in agreement with the engineering tendency to recommend smaller instruments than formerly, with more compact switchboard and control board designs. The manufacturer points out that these new lines will hasten the time when the switchboards for the largest power plants will be miniatures of the types heretofore used. These new a.c. instruments are on the same basis of design and application as the recently announced d.c. instruments which they match in appearance, thus forming a complete and harmonious line of instruments of both a.c. and d.c. types.

The Cutter Company, of Philadelphia, Pa., is now manufacturing as a separate device which may be fitted to any rotary control, the I-T-E "Synchronism Actuated Lock-Out Feature." This is for use in connection with starting and running switches for synchronous converters to the end that the switch may be passed into the running position only when the rotary which it controls is in approximate synchronism with the system to which it is to be connected.

The General Electric Company has developed a new type of induction overload relay which has a target that is built in the relay and indicates when the relay has functioned to trip the particular circuit which it controls. The contacts are definitely geared to the shaft. The holding coil of these relays, therefore, does double duty in that it holds the contacts closed after they have once been closed in any cycle of operation and also operates the target. This relay can also be provided with undervoltage protection.

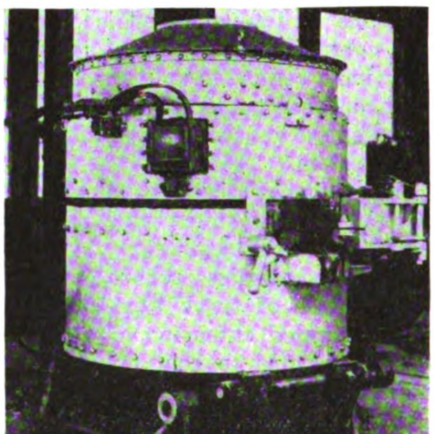
The Westinghouse Electric & Mfg. Company has built an operation indicator which shows which relays have operated during a system disturbance and aids in adjusting the operation of the relays by locating the cause of the disturbance and fixing the responsibility for it.

James G. Biddle, Philadelphia, Pa., has brought out two new insulation testers known as the "Meg" and "Super-Meg." These two new instruments are an addition to his line of "Megger" testing sets and the maker points out that they meet a definite need for portable, insulation-testing instruments at a lower cost than heretofore.

Industrial Heating

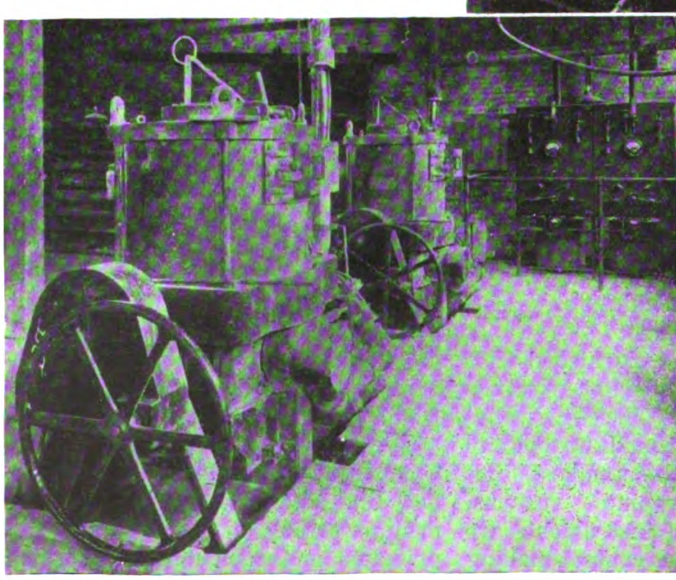
Heating Units.—The Edwin L. Wiegand Company, Pittsburgh, Pa., has placed on the market Chromalox strip heaters which can be secured in varying lengths from 12 in. to 6 ft. with wattage and voltage as required. The heating element in these heaters is nickel-chromium ribbon, which is embedded edgewise in a refractory material under hydraulic pressure of 100 tons. The embedded heating element is entirely enclosed in a rust-resisting iron, or Monel metal, and the embedded terminals are of patented construction joined direct to the resistor without the use of screws or brazing. The manufacturer states that these heating elements have been designed to withstand wide variation in voltage and temperatures up to 1,400 deg. F. without danger of injuring the element or terminals. Their construction prevents oxidation or external misuse damaging the heating element.

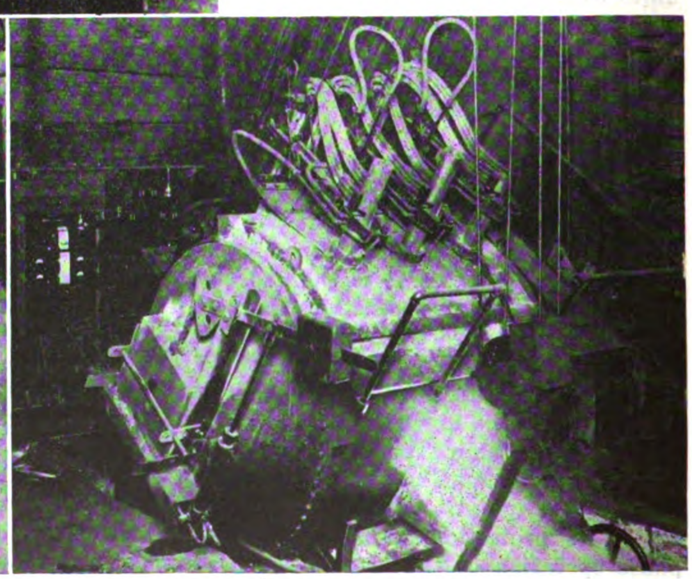
The Cutler-Hammer Company, of Milwaukee, Wis., reports that new and unusual applications are constantly being made of the C-H space heater. Recent unusual applications are in gum drying ovens, film drying



Resistance-type furnace made by Baily Furnace Company of Alliance, Ohio.
This furnace has a new radiant dome that eliminates the usual trough supports. The lower picture shows a tilting furnace made by Green Electric Furnace Company of Seattle, Wash.

Repulsion-induction furnace made by General Electric Company of Schenectady, New York.
The force of magnetic repulsion existing between transformer primary and secondary windings is utilized to cause a circulation of molten metal between the heating circuit and the melting pot.



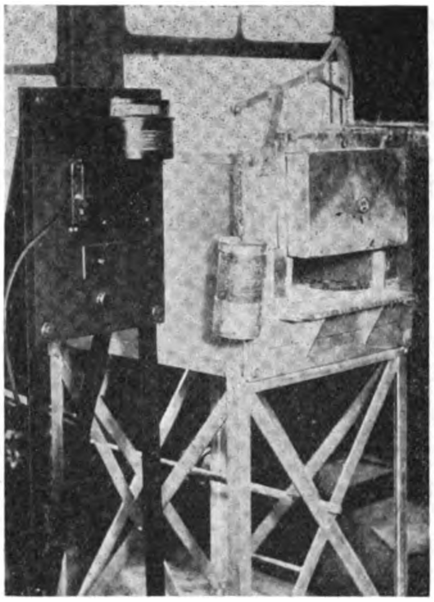


ovens and in investigating the tensile properties of cotton yarn.

Extended use has also been made of space heaters made by the Russell Electric Company, Chicago, Ill. Each is an independent 500-watt heater with 22.75 in. mounting centers so that as many as required can be easily installed.

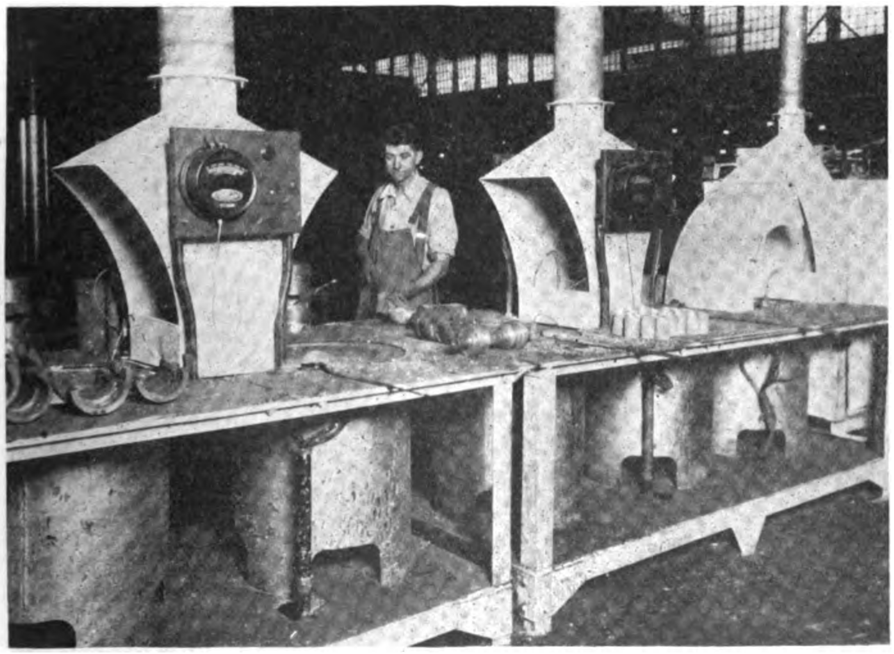
The Wireless Resistor Company of America, at Milwaukee, Wis., has put on the market a new non-metallic resistance element known by the trade name of "Globar." The material constituting the element is, in part, silicon carbide and somewhat resembles the compound which is known commercially as carborundum. The material is moulded into round bar shapes and is mechanically strong and rigid regardless of the temperature applied. The manufacturer states that "Globar" may be operated at temperatures up to 2,400 deg. F.

A very interesting industrial application of electric heating has been made by Freyn, Brassert & Company, Chicago, Ill. The application is a heater for preheating the finishing rolls of sheet and tin mills. The advantages claimed for electric preheating, compared to previous methods, are that the heat may be more evenly applied to the rolls and that more accurate control of the amount of heat applied is obtained. This results in reducing roll breakage and increasing production due to the fact that the rolls can be brought nearly to normal operating temperatures and shape. The maker reports that so far this has not been obtained by any other method of preheating. The heat is applied to the roll by means of special strip heaters assembled on a framework that fits them closely around the rolls. The framework is designed so that it may be quickly clamped or released from the rolls; consequently little time is lost when making the change. An installation is shown on page 69 of this issue.



Electrically-heated furnace for heat-treating steel made by Westinghouse Electric & Mfg. Company of East Pittsburgh, Pa.

The temperature is maintained automatically by means of the control relays shown at the left of the furnace.



Electrically-heated solder pots of 750-lb. capacity made by Westinghouse Electric & Mfg. Company of East Pittsburgh, Pa.

Automatic temperature regulation is maintained on these solder pots by means of the control panels shown in front of the pots.

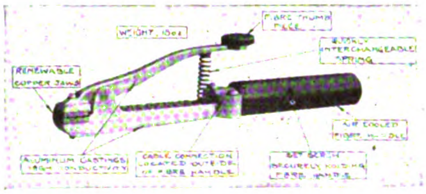
The Westinghouse Electric & Mfg. Company reports that electric heating is continuing to find favor in the industrial world for certain applications, one of which is electrically-heated solder and babbitt pots. Solder and babbitt pots of 150- and 750-lb. capacity, with automatic temperature regulation, have been developed by this company. Here again temperature regulation applied to a soft metal melting pot of this character is a distinct step forward in the industry.

Electric Furnaces.—The Bailey Furnace Company of Alliance, Ohio, has recently developed a new radiant dome electric furnace for melting brass and nickel alloys. The maker points out that this furnace embodies some radical features as it completely eliminates the usual trough supports formerly required by resistance-type furnaces, the resistor ring being entirely self-contained in a separate middle section. It has the advantages of heating up more rapidly than other furnaces of this type and a much higher melting capacity than was formerly thought possible in a resistance-type furnace.

The Green Electric Furnace Company, Seattle, Wash., has made an effort to standardize its electric steel and iron melting furnaces so that they will operate on the standard 220-volt, three-phase power circuits. The maker states that the necessary range of voltage between electrodes is provided by means of a voltage regulator which is really an autotransformer taking current at 220 volts, three-phase, and supplying current at any voltage required between 90 and 140 volts. The manufacturer reports that he has further improved the furnaces so as to make them operate with a very low power demand; hence, when it is desired to melt slowly the power may be used in such a manner as to create a high load factor and therefore a low cost per kilowatt-hour.

The General Electric Company has developed and made installations of a new type of induction furnace, which utilizes the force of electromagnetic repulsion existing between transformer and primary and secondary windings, to cause a circulation of molten metal between the heating circuit and the melting pot. The maker reports that a notable accomplishment of the repulsion-induction furnace was the successful melting of pure copper on a commercial basis.

The Westinghouse Electric & Mfg. Company states that its arc-furnace automatic regulator has been brought to a higher degree of perfection than ever before and is now being widely used.



New welding electrode holder made by Gibb Instrument Company of Bay City, Michigan.

The Electric Furnace Construction Company of Philadelphia, Pa., is introducing Soderberg electrodes—an electrode developed in Europe and for which the maker reports a lower first cost, reduced consumption, and continuous furnace operation, no time being lost for changing electrodes. The Soderberg electrode is a continuous electrode, made, baked, and consumed in the same furnace. A raw mix of carbonaceous material is tamped into a ribbed cylinder of light gage metal, thus forming the electrode. The baking process is accomplished by the waste heat from the furnace. As the electrode is consumed, it is lowered into the furnace and new sections of casing are added at the top as required.

Electric Welding.—The Allan Manufacturing & Welding Company, of Buffalo, N. Y., has developed a polyphase arc welder. The maker states that this welder is a specially-constructed transformer which is fed from a polyphase, a.c. power line and transforms the current to the proper voltage and amperage required for successful arc welding. The welder is constructed to suit any alternating-current primary power supply as to voltage and frequency.

The Liteweld Company, of Cleveland, Ohio, has developed a portable, arc-welding generator with a "divided pole" construction which, it is claimed, reduces from 40 to 50 per cent the active material required in a machine of a given capacity. The maker points out that this results in a smaller machine without loss of power, efficiency or reliability.

The Gibb Instrument Company, Bay City, Mich., has put on the market a new welding electrode holder. The maker points out that it is made of cast aluminum and weighs only 15 oz., that it has renewable copper jaws, and that the holder remains cool because of the high conductivity of the aluminum members, of a special, air-ventilated handle, and because of its outside cable connection.

Repair Shop Tools and Supplies

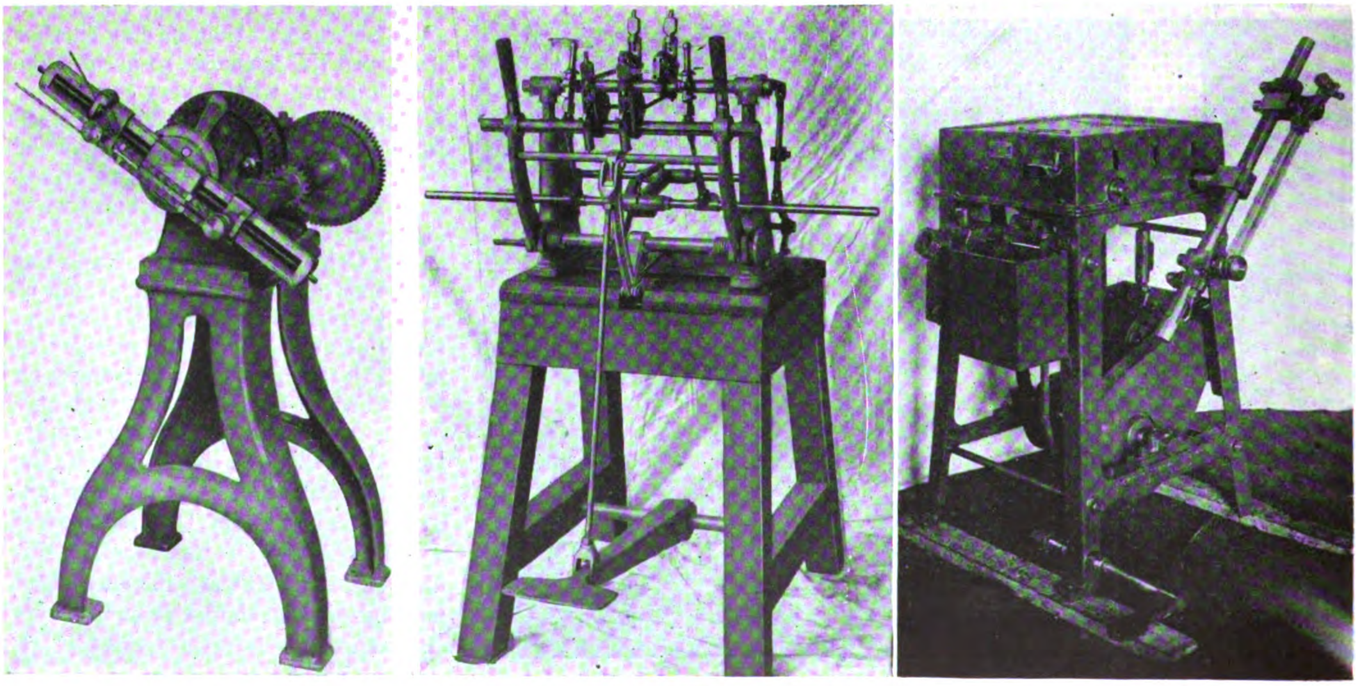
Winding Machines.—The Mutual Foundry & Machine Company, Atlanta, Ga., has recently developed a combination reel rack and tension device, which is designed for handling a maximum of nine 24-in. reels. The tension device has slots for nine wires and is so arranged that individual tension may be applied to each wire, thus insuring uniform tension on a multiple-wire coil. This company has added a self-contained motor sub-base carrying a 1-hp., 1,750-r.p.m. motor, to its Browning coil winder.

W. P. Hunsdorf & Company, of Cleveland, Ohio, has developed a high-speed "pin-coil" winder for which the advantages of quick adjustment, easy operation, and a pin spacing which remains as set, are claimed. This company has also developed a new coil-duplicating machine.

The B. T. Coil Former & Tool Company, of New York, N. Y., has developed a new combination coil winding and spreading machine. The maker points out that this machine produces a rigid coil that rarely requires varnish to hold it for taping. (*Continued on page 104*)

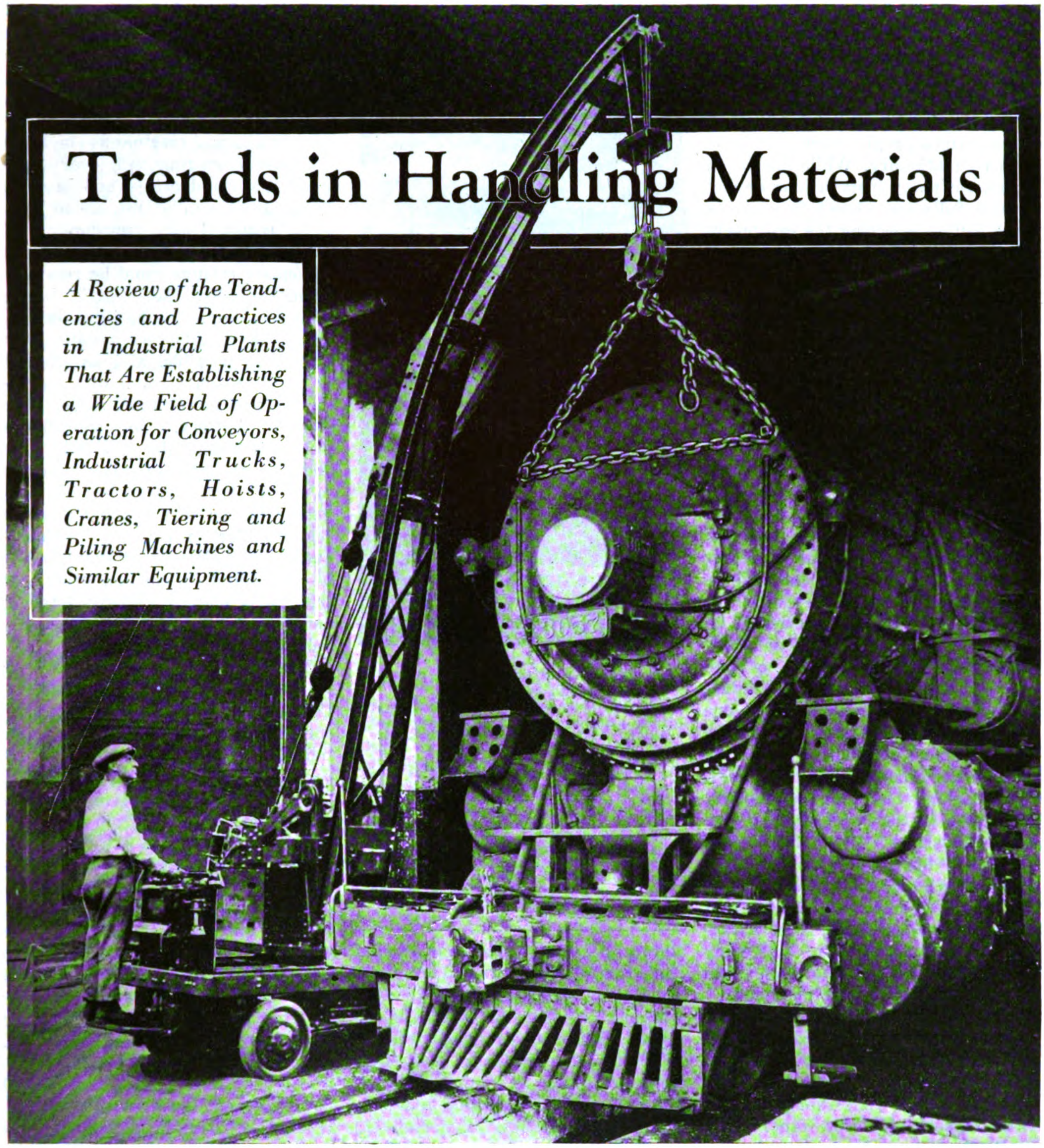
Some recently developed coil winding machines that will save money in the armature repair shop.

The left-hand machine is a high-speed "pin-coil" winder made by W. P. Hunsdorf & Company of Cleveland, Ohio. The center device is a coil duplicating machine made by the same company. The machine, which is illustrated below on the right, is a coil winder equipped with a self-contained motor. This winder is made by the Mutual Foundry & Machine Company at Atlanta, Georgia.



Trends in Handling Materials

A Review of the Tendencies and Practices in Industrial Plants That Are Establishing a Wide Field of Operation for Conveyors, Industrial Trucks, Tractors, Hoists, Cranes, Tiering and Piling Machines and Similar Equipment.



Using a 19-ft. boom industrial crane truck in assembling the front smoke box cover of a locomotive.

By FRANK E. GOODING

Associate Editor, Industrial Engineer

UTILIZATION of material-handling equipment in industrial plants in place of man-power has been undergoing a gradual growth for years. When Ford introduced conveyors in the processing and assembly of automobiles, although this was not the first such application, the possibilities were perhaps more forcibly broadcast than ever before to the attention of the industrial public. Other automobile companies quickly followed this lead until the automotive industry has, more than any other, developed material handling to suit its own needs. Conveyors, as in the early days of the industry, still form the nucleus of material-handling and assembly systems, but the modern automobile plants now take advantage of industrial trucks—both hand and electric—tractors, hoists, trolleys, cranes, and other types of material-handling equipment.

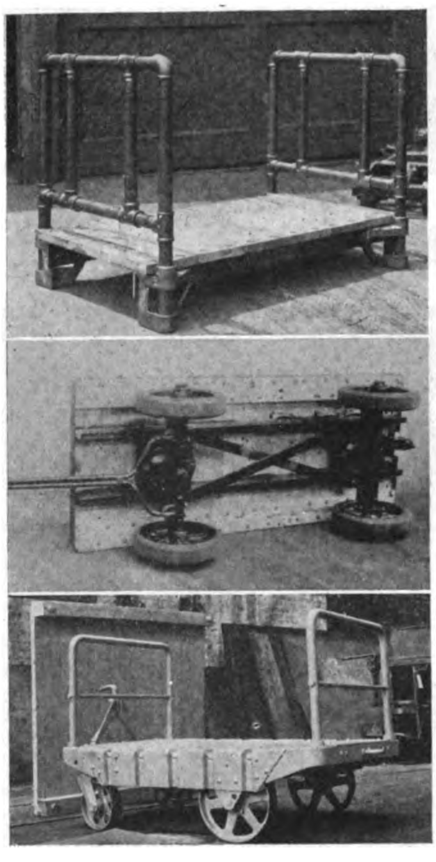
Developments through recent years have emphasized the need of special study in the applications of equipment to special work. This requires a consideration of the product and quantity handled. What might be best for one plant might not be suitable for another, even though producing a similar product. An extreme example may

be taken from the automotive industry. Here the large plants could not get along without conveyor assembly; in contrast a small plant, producing only a few cars a day, would find it much more expedient to move the workmen progressively and leave the cars stationary. While this seems axiomatic, many installations are not always fully considered from every angle before selecting the equipment for the job. Sometimes conveyors are used when industrial trucks or trolleys would be more satisfactory. The contrary is also true. Users are, however, obtaining a better knowledge of the problems involved and the methods of solution so that they can more judiciously apply this knowledge to the selection of the most effective equipment.

During the war and in the prosperous period which followed, labor learned to shun work which required heavy lifting and carrying. Immigration restrictions together with the change in the class of those immigrants received prevented the replenishing with a new class of labor to do this work. This naturally called for the substitution of mechanical means for muscle in handling heavy units and has been one of the principal reasons for the wider demand for material-handling equipment during the past year. This demand has been particularly noticeable in the hand-lift and electric industrial truck fields—two classes of tools which have a wide application in all industrial lines and can also be used to decrease the cost of miscellaneous handling of a varied line of material in its many movements through the shop from its receipt until it is shipped out.

Almost any shop which handles even a comparatively small quantity of material will find that it can use either a hand or electric lift truck advantageously even though it has little opportunity for other such tools except possibly a hoist or piling machine. Many large plants find that these machines often work into the material-handling scheme for the miscellaneous work which does not travel over the fixed path to which a conveyor or hoist is limited.

In general, the developments for 1923 in the industrial truck field have been toward the production of heavier equipment by the concerns who have had the most extensive experience. There was a similar development during 1922, but this tendency was more marked last year.



A skid or platform for an elevating truck and two trailers.

The pipe ends may be removed so that this Cowan platform may be used alone. A similar type with higher legs is made for an electric truck. The middle view shows the construction of a Cowan trailer and the way it is connected up to track. This all-steel Elwell-Parker trailer (below) weighs 600 lb. and is capable of carrying a load of 6,000 lb., either as a trailer or to be carried on a heavy-duty industrial lift platform truck. For hard, severe service many users are turning to steel platform and tote boxes; such as the Truscon. Steel platforms and boxes are necessary if hot forgings or similar material is to be transported.

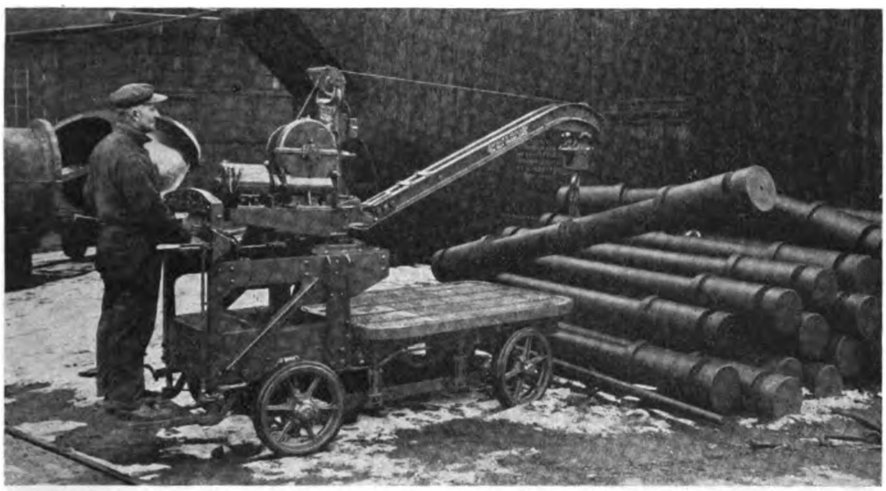
Before the war it was seldom that more than 3,000 lb. was carried as a truck load, with the average load running less than 2,000 lb. As users of this type of equipment became more familiar with these tools, they were prompted to apply them to more specific work, so that today we find them handling materials in practically every department of an industrial plant and operating not only on floors, as originally intended, but in unpaved yards, up inclines, through tunnels, across bridges, and in fact, anywhere that one could possibly handle a load on a hand truck.

Numerous types of accessories have been applied to these equipments in order to especially adapt them for the job in hand. The requirements of some of the applications naturally have exceeded the strength of the original designs and have often revealed weaknesses. Sufficient demand for these special tools has naturally resulted in the standardization of improvements to overcome these weaknesses.

These conditions have resulted in the demand for larger electric industrial trucks and tractors as the loads are now averaging well over 4,000 lb. in many industries, and in some exceptional installations, above that. This required the revamping of many types in order that the same nameplate ratings could be retained. Fundamentally, the electric industrial truck must be as light as possible, as flexible as possible, as strong as possible, and as efficient as possible—on account of it carrying its own power unit, namely, the storage battery, no superfluous weight is permissible in a truck. In addition, the kind of labor available to operate these trucks was not altogether of the sort which has much respect for machinery. Consequently, the element of abuse had to be considered in the new design, so that today electric industrial trucks and tractors have been designed not only for use but against abuse.

The rating of "tructors" (a term which The Elwell-Parker Electric Company, Cleveland, Ohio, has coined as descriptive of the electric industrial truck or tractor and advocates its general use by all manufacturers as descriptive of this equipment) today is from 50 to 100 per cent greater than it was in 1913. However, the weight of the equipment has been increased on an average of only 33 to 66 per cent when in some special cases, such as crane trucks, capacities have increased in a ratio of 6 to 1, or 500 per cent with an increase in weight of only 3½ to 1, or 250 per cent. In line with these demands of industry, two or three manufacturers of electric trucks have produced a special power crane truck with a 12-ft. boom for lifting and piling. This may be used to enter railroad cars, to load or unload, to set or remove dies, to place or remove heavy parts on machine tools, for piling or unpiling castings or other heavy stock, and other heavy lifting or handling and moving.

If the distance to be traveled is short, as from the inside of a car to a truck or nearby storeroom, this crane tructor is generally used to do both the lifting and carrying. If the distance is considerable, however, it is more economical to deposit the load on another truck or



One man could not pick these up alone without a crane such as this.
Crane trucks, like this and others shown on the accompanying pages, enable one man to pick up heavy pieces of material almost anywhere in the yard and deliver them in any of the shops. This Crescent truck has a capacity of 1,500 lb. and is of the high-wheeled type.

trailer for the long haul. However, for much of the miscellaneous handling of heavy material about a yard or plant, the crane tructor not only picks up but also carries its load to its destination. In several installations magnets are used on the crane to handle pig iron and scrap, either in yard storage or to load or unload gondolas or the industrial trucks or trailers which are used to carry the iron to the cupola.

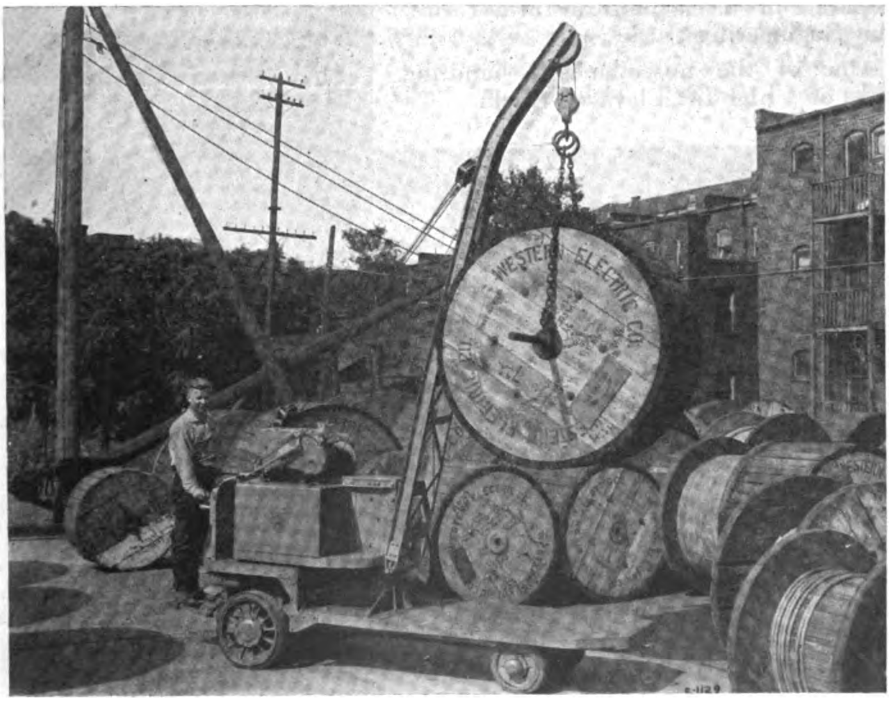
These crane trucks have a lifting capacity of about 3,000 lb. at a radius of approximately 6 ft., and 1,000 lb. at a radius of 12 ft. A special 19-ft. boom is sometimes added when the crane is used on high work, such as in locomotive repair shops for fitting or removing smokestacks. This can also be used for fitting or removing other heavy parts such as pumps, smoke box fronts, springs, wheels and axles, pistons, crossheads, and other heavy parts which are not so high and could be reached by a truck with shorter boom.

Another tructor development has been along the line of a high-lifting elevating platform truck which will lift from a low height of about 12 in. to a top height of about 60 in. These are called "Hi-Lo" tructors, or tiering or piling trucks. They are commonly used to pile material, to place or remove dies, to load box cars or motor trucks, and to handle material on platforms which must be raised more than the ordinary elevating platform is capable of doing. With the "Hi-Lo" the skids or platforms, with load, may be stacked. One plant, with material which cannot be piled very high, even uses these "Hi-Lo" tructors to elevate loaded platforms so that they may be suspended from the ceiling and in this way get the full storage capacity of the room. Most of these tructors have a capacity of 5,000 lb. and serve as an all-round, general utility truck. Neither this nor the crane truck, however, is expected to be used where sufficient straight hauling is on hand to keep an elevating platform or tractor and trailers busy. Several adaptations of this high-lift elevating platform tructor have been made for special work. The use of one of these for handling tin plates is shown in an accompanying illustration.

The recent developments of the various larger manufacturers of tructor equipment have not been entirely uniform because in some cases developments have been made previous to this year, while other manufacturers took the opportunity to complete practically a full line of electric industrial trucks and tractors for all the various industrial applications.

In the endeavor to complete his line of trucks, one manufacturer has added a chisel-platform, electric lift-truck in which the chisel teeth project forward from the truck almost level with the floor and slip under the load and elevate it. With this one man can pick up almost any load and deliver to its destination alone. The application of this was discussed in an item in the INDUSTRIAL ENGINEER, on page 561 of the November, 1923, issue. Another company has developed a special, low-platform, general utility truck which may be provided with a boom crane, a demountable dump body or used for general all-purpose hauling. Another manufacturer has produced an attachment which is placed on a low-platform electric truck and makes it a hand-operated, elevating-platform truck.

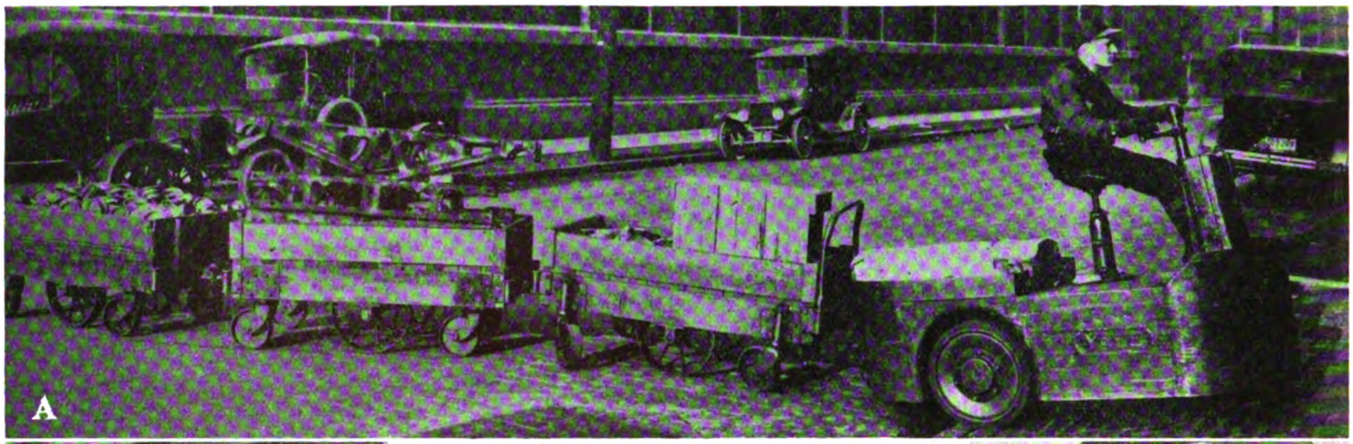
Recently a few manufacturers have begun the development of a line

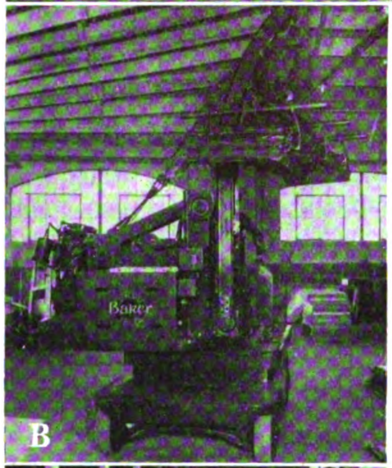


An example of a yard application of a long-boom industrial crane truck.
This truck can run alongside a row of these cable reels and lift any one from the group. During the past year many long-boom trucks have been installed in railroad shops for fitting and repair work around the locomotives. This Elwell-Parker truck has many other industrial applications, such as piling or unpiling, setting dies, assembly work, and many other miscellaneous tasks which would be light for a large locomotive crane.

Tractors and Trailers for Industrial Hauling

Eleven Examples of What This Equipment Will Do





A—New three-wheel type of Yale tractor with train of six-wheel trailers.

B—Baker R & L crane truck with load of thin sheets.

C—Handling a load of 5,500 yards of cotton goods with a Lewis-Shepard hand-lift truck.

D—This three-wheel gasoline Clark truc-tractor will crane 2,000 lb. or tow one to twenty trailers.

E—Loading cars with a Yale high-lift elevating platform truck.

F—Using a Cowan electric truck as a tractor and trailing Cowan hand-lift trucks.

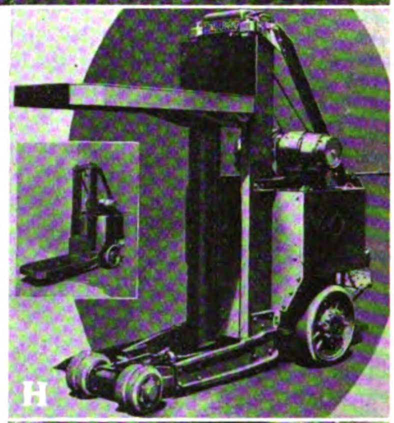
G—A new type of Mercury three-wheel, internal-gear tractor with trailers.

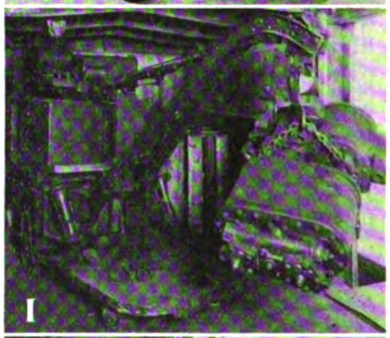
H—Elwell-Parker "Hi-Lo" truck with platform at top and bottom of its travel.

I—Depositing 1,800 lb. air receiver in box car by aid of Elwell-Parker crane truck.

J—This crane attachment is built on a separate lift-truck platform for a Terminal Engineering truck.

K—One of the miscellaneous handling jobs of a high-lift Elevayor truck.





of light-duty electric elevating- and stationary-platform electric trucks with the idea that there was sufficient demand for a standardized truck of this sort. Similarly, one producer of high-wheeled electric tructors which are particularly adapted for use on yards and over rough floors and passageways has added a crane truck to his line of equipment. Another manufacturer of similar equipment has provided a special skid with a crane attachment which may be lifted by the elevating mechanism of the truck as is any other platform. The crane motor receives its power from the battery and in this way the regular truck may quickly become a crane truck. The crane platform may be as quickly set to one side and the truck again used for regular work.

Practically each manufacturer of electric and hand truck equipment has produced a special, steel-reinforced skid or platform which is shipped knocked-down to the user. Originally, most platforms were made of wooden planks by the user according to his own ideas. Many of these were improperly designed and would not stand up under service. Manufacturers now realize the importance of good skids or platforms to assure the reliability of service of which a tractor or hand-lift truck is capable.

Considerably increased demand has been shown for steel platforms, particularly with the addition of a box to hold material, especially around foundries and shops engaged in metal manufacturing where the abrasion of the parts would soon wear out a wooden tote box. While these originally were designed for use in handling hot forgings, their lasting qualities have brought them into much wider use. Four-wheeled trucks and trailers are also made with steel platforms, as shown in the accompanying illustrations. In this case the truck is made so that it can be used as a trailer, can be lifted by an elevating platform truck and carried, and is also arranged so that it can be lifted by an overhead traveling crane. This flexibility of units adds much to the value of material-handling installations.

One type of platform is made to use on either a hand or electric lift truck; the hand-lift truck lifts the platform endwise and the power truck crosswise. Manufacturers of hand trucks, live-platforms and trailers are using ball-bearing casters more commonly. One manufacturer of casters has produced a double-ball-race caster for this purpose.

Recent Developments in Other Material-Handling Equipment

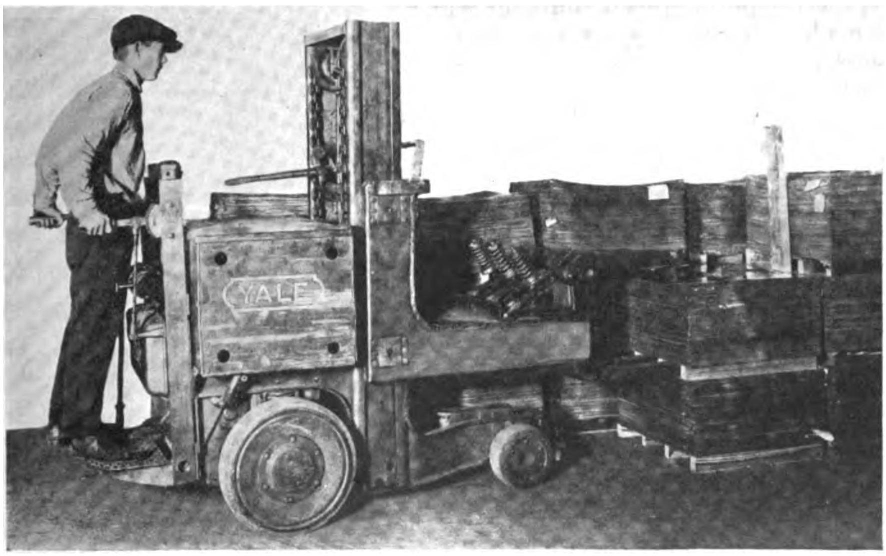
Developments in the hand-lift truck field recently have also been towards the providing of equipment which would handle heavier loads. At present, hand-lift trucks which will handle up to 15,000 lb. may be obtained. One company has developed the trailing of loaded hand-lift trucks behind tractors or other electric trucks, as shown in an accompanying illustration.

Two or three manufacturers have added three-wheeled tractors to the line of tractors and industrial trucks which they were already manufacturing. One well-established company has added an internal-gear-drive tractor to its line, making it a producer of both worm- and internal-gear-driven tractors. The manufacturer claims considerable increase in efficiency of this tractor by using the internal gear. A manufacturer of a gas-driven tractor has added a special crane for loading trailers or general utility purposes, as shown in an accompanying illustration.

During the past year or two several companies have brought out new designs of piling or tiering machines. One, for example, has been of a light capacity—up to 500 lb. This is made in both hand and electric types. The electric type, it is claimed, can receive its power from a lamp socket. Larger units require a power circuit.

Another company which manufactures a wide line of tiering machines from small capacity up into large units has developed a special telescoping frame, whereby the equipment is able to operate anywhere from about 6½ ft. up to full height of the telescopic attachment. This machine can pile under a sloping roof, under or on top of a balcony, around beams, or other obstructions overhead and in similar places where a tiering machine of fixed height could not operate. With this machine the frame is made in two parts, one telescoping within the other. In the telescoping-frame tiering machine the platform is fastened to the telescoping part and is elevated first to the top of this section. When it reaches the limit the telescoping frame is then raised, so that the load is always at the top of the telescoping frame. Several four-poster tiering machines with large platforms, in some cases large enough to handle automobiles, have also been developed. In addition, many users of piling machines who have purchased hand-operated equipment are adapting them to electric drive by the addition of a motor.

Probably but few plants handle so little heavy material that they do not have an opportunity to use a hoist or crane to advantage. This type of equipment is occupying an ever-increasing place in industrial material-handling applications. Men dislike heavy lifting, as was mentioned. It is also slow work and

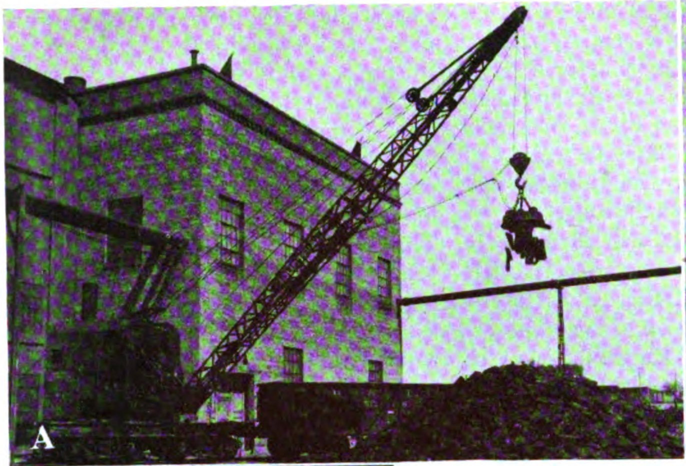


This is a standard type of electric truck modified for special work.

A Yale high-lift, elevating-platform truck has the platform and the wheel base shortened, and fingers, together with clamps, are provided for handling tin sheets. Instead of using skids, as is required in other work, the piles are separated by small pieces of plank just high enough to enable the fingers to slip in between the layers.

Types of Equipment for Handling Materials

Some of These May Be Used in Almost Any Plant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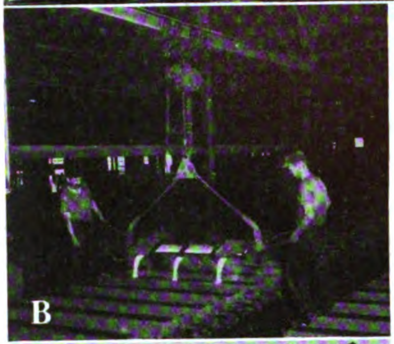
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A—Handling pig iron with an Industrial Works locomotive crane and magnet.

B—Pouring cast-iron pipe from a three-lip flask carried by a Motorbloc hoist.

C—This electrically operated Jeffrey stacker with telescoping arm for raising and lowering will handle about 500 bags per hr.

D—Old type of Standard disk roller conveyor handling shingles. The manufacturer is again introducing this type of construction.

E—Economical storing and reclaiming of coal with a Godfrey conveyor and clamshell bucket.

F—Driving mechanism and Jeffrey conveyors for handling automobile bodies.

G—Unloading and piling pig iron with a Shepard hoist and magnet.

H—Silent Hoist capstan and car puller operated by an electric motor.

I—Gasoline operated Standard portable belt conveyor for handling coal and other loose material. Electric motor may be attached if desired.

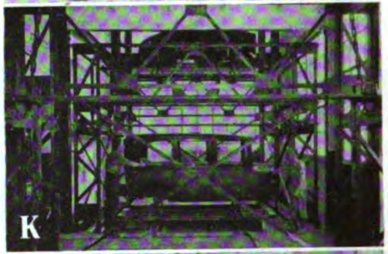
J—A Jeffrey portable belt conveyor which is made either to suspend from slings, as shown, or to be carried on wheels for yard work.

K—This Jeffrey lift or tray elevator carries the automobile bodies from one floor to the next.


H


I


J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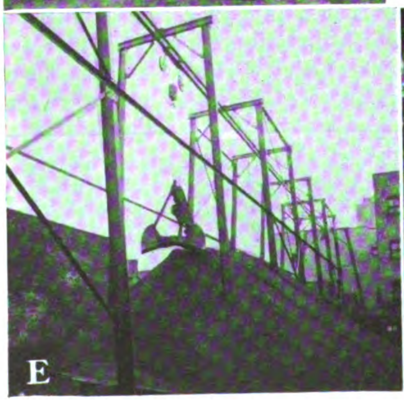
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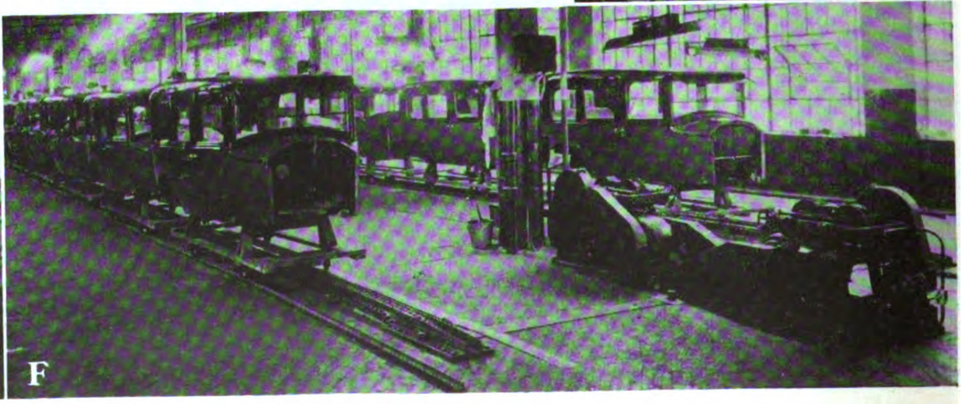
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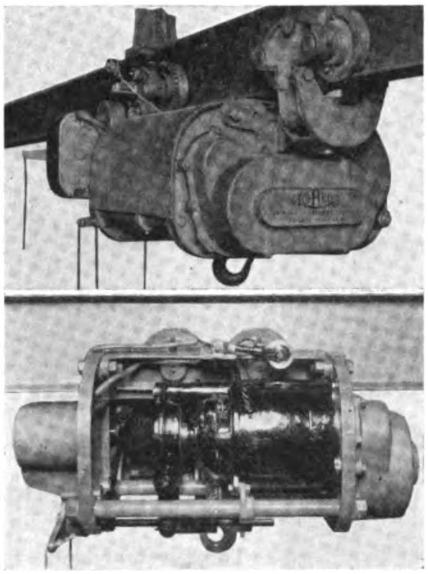
often requires a helper. It does not pay to keep a machine idle long while waiting for a helper or while waiting to place or remove a heavy piece on a machine tool. If a hoist or crane is provided for that tool, it is always on hand and in many cases will soon repay its cost through the increased production or decreased wage expense of a helper.

An interesting example in one industrial plant indicates the trend in hoist applications. In this case a hoist served one of a group of machines. This machine was the bottle-neck in the line of production, and choked up a process wherein the work flowed through several machines. The slow-speed hoist feeding this machine was supplanted by one of a faster type. Also, it was provided with special devices for quickly gripping and releasing the work. This speeded up this machine enough to enable it to keep up with the capacity of the others in the group. This does not mean, however, that the field for slow-speed hoists is decreasing, as there are many places in which they still operate as fast as is necessary. A study of quick-gripping devices adapted to the service requirements of a hoist shows that these still offer considerable opportunity for development.

Recently at least two companies have produced an electric hoist which will operate with very low



Two views of the "Lo-Hed" monorail electric hoist.
This is an end view and a side view of a 3,000 lb. American "Lo-Hed" monorail electric hoist. The side view, with cover removed, shows the accessibility and convenience as well as the arrangement which makes it possible to raise the hook so high.

headroom. These are particularly advantageous in the older constructed shops where the ceiling is low. The other hoist, which is really a chain block with an electric motor attached, is finding considerable application in fields where the hoist must be moved frequently, as on maintenance work and other places where it is used temporarily, because it is of a lighter weight than the standard electric type of hoist. Another manufacturer of a wide line of electric hoists has standardized on hoists of 500 to 2,000 lb. capacity with worm drive instead of internal gears.

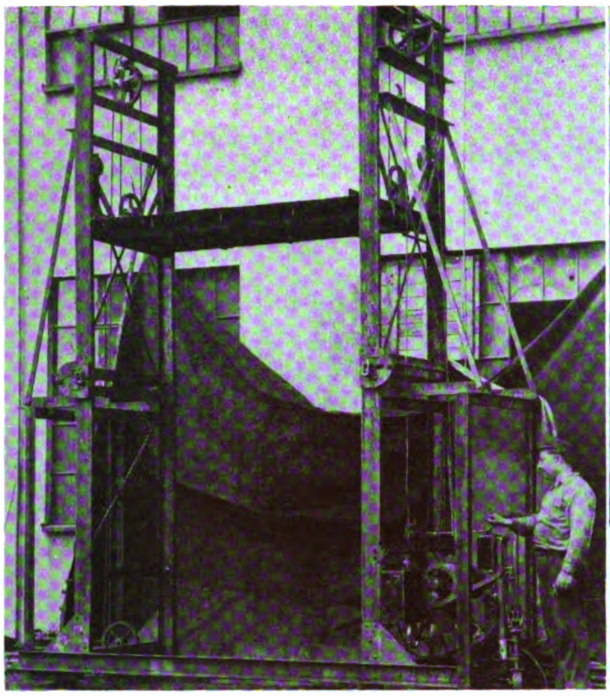
There is also an increasing number of yard and shop applications of the cage-operated electric hoist on monorail and crane crossovers. One of these recent applications is pictured in one of the accompanying illustrations. These hoists will cover a wide area in any industrial works and tie together the transportation between several separate units.

There has been considerable demand from medium and small plants for cranes, hoists, and portable conveyors, as will be explained later, for use in handling coal to and from yard storage and also around the boiler plant. Large plants which have done considerable coal storage have been fairly well provided with this equipment. The older constructed plants and smaller plants are realizing that it is costing considerably more money to handle the coal as received and are installing mechanical devices to do this. As coal handling is an intermittent process, the use of material-handling devices to supplant gangs of men has resulted in worth-while economies even where no effort is made to store more than enough for ordinary requirements.

Numerous lines of industry have noted the advantageous application of conveyors for production and assembly in the automotive industry and are now applying some of these plans to their own lines. One application of a belt conveyor for assembly of small parts is shown in an accompanying illustration. Here radio parts are inspected and assembled progressively until they are finally boxed and thrown into the center section of the belt conveyor which carries them to a cross conveyor at the distant side of the room. This cross conveyor in turn deposits the boxed radio parts in the stockroom. Here, one line of belt conveyor is serving not only two rows of assemblers but also carries away the finished parts. Notice particularly the deflectors which are used to remove the parts from the conveyor belt and deflect them to each operator.

This conveyor does away entirely with the use of containers of any sort, which it would ordinarily be necessary to use to carry the parts from one worker to the next. It also acts as a pace-maker for the entire

When a locomotive crane is corduroy-mounted, it can go anywhere.
With this Pawling and Harnischfeger crane advantage can be taken of irregular spaces for storage as the whole yard is within its working range. These are made for either gasoline or electric drives. Electric drive is preferred where the machine does not have to cover too great an area. Plugs can be located at convenient places about the yard and a long flexible cable used to transmit power to the machines. As the machine moves beyond the reach of one plug, the cable is transferred to the next.



Three recent developments in the construction of tiering or piling machines.

The four-poster Lewis-Shepard tiering machine (left) is used to handle large rolls of paper for a St. Louis newspaper. The machine above (New Jersey Foundry & Machine Co.), has a platform 6 ft. long and is used to handle plate glass mirrors between the floor and a mezzanine. The frame is of wood so as not to break the plate glass mirrors. The Economy telescoping-frame tiering machine (right) is used to pile on or under balconies, around trusses, and in other similar places where it is difficult to use a machine of fixed height. The trussed part of the framework shows the minimum frame height of this machine; the position of the bale indicates the maximum extended height. These heights can be made to fit almost any ordinary condition. Considerable recent development has been made in adopting higher speeds than has been the former practice for tiering machines.

line of assemblers. Another advantage is that work of this sort can be put on a group wage-payment plan and instead of checking the production of each individual worker, it is necessary to check only the output delivered at the end of the line, as each worker will necessarily do his or her part progressively. This simplifies the checking and recording of work done but does not interfere with varying the proportion of the pay to different operators according to the skill required, the experience, and the difficulty of the various tasks they perform.

One of the interesting developments in conveying equipment during the past year has been in applying it to special industrial applications where until recently conveyors have not been considered as possible for use. The use of conveyors in shipping rooms has been extended. The particular advantage here lies in the ease and rapidity with which the packages are removed from the packer and placed in the shipping department. Many companies are, with the aid of conveyors, now able to fill orders from their shipping room within a few hours instead of requiring days as was often necessary before. Pneumatic tubes for delivering these orders to the shipping room are also installed in a number of cases to assist in speeding the shipment of an order by getting it to the packing room almost immediately after it is entered on the books.

In many lines of work there seems to be a tendency toward using ball-bearing conveyor rolls of small diameter, as they will carry smaller pieces, and do it more smoothly, then the large roller conveyors.

One company has put out a special conveyor which consists only of a disk roller, as shown in one of the accompanying illustrations. This is fastened to an angle iron and is made in both straight and curved sections. The particular advantage of this conveyor is the ease with which it may be erected and adapted to wide or narrow boxes or other units which it is to carry. Although this is not entirely new, no conveyors of this type have been

One of the many uses of a high-lift elevating platform industrial truck.

This Baker R. & L. truck can be used to place or remove a double tier of hogsheads of tobacco either in the stockroom or when loading or unloading motor trucks. With this a motor truck can haul almost twice as much as if loaded by hand. Similarly the storeroom can pile almost twice as much material on the same floor space.

manufactured for a number of years until recently.

One use for conveyors which has become more common in the last few years is to provide long conveyor systems so that goods may be loaded on the conveyors and remain until used. In this way the conveyor section acts as warehouse storage space. One concern uses a four-floor spiral for this purpose.

An example of the extensive use to which conveyors are being put in manufacturing and assembling processes is shown by an installation of eighty-seven conveyor systems in six plants of the Fisher Body Corporation during the past year. The automobile bodies are carried through the building, painting, drying and trimming operations and on to the shipping department by conveyor. In some cases the bodies are transferred from one conveyor line to another by hand. At other places this is done automatically as, for example, by the tray elevator, as shown on page 86.

As the lubrication of a conveyor system is one of the important factors in its effective operation, one of the companies has devised a special grease gun for this purpose.

To meet the industrial demand for yard service work some concerns have added to their line locomotive cranes provided with crawler or corduroy mountings so that they are not dependent upon railroad tracks or even upon a solid roadway for locomotion. These may be operated by either gas or electricity and are arranged to use either magnets, grab buckets or crane hooks, for the variety of work which they are required to handle. An installation of this kind is shown on page 86.

To aid industrial plants in the handling of coal, ashes and other loose material around the plant, either for transferring it a short distance or elevating it on trucks or piles, one company has built a standardized, portable-belt conveyor. This may be used in series to feed others and transfer coal some distance. Ordinarily, this is placed with the loading end at the dumping place of a gondola and the coal is shoveled into the conveyor. This elevates the coal into a truck which hauls it to its destination. These conveyors are driven either by an electric motor or a gasoline engine, as desired. This was described on page 369 of the July, 1923, issue of INDUSTRIAL ENGINEER. Another heavier model of somewhat greater length has been produced during the past year by still another concern. One development has been a slatted pulley which is used at the lower end to prevent loose material from wedging in between the pulley and belt.

Although stackers or pile elevators are not new, there has been sufficient demand for an additional type being produced during the past year. This is a self-propelling unit and is constructed to deliver the bags or bales of material from about 6 ft. in height to a maximum height of 25 ft. It will handle about 500 bags per hour, and may be used for either piling or breaking down a pile. This stacker raises and lowers its boom by power and also is run backwards and forwards by its own power, supplied by a gasoline engine or an electric motor.

The developments and extensions of material-handling equipment during the past year have affected practically all lines of industrial activity. It would be astounding to count the number of times material is handled in the ordinary shop and estimate the total weight in all those handlings from the time the raw material is received until it is finally shipped out. Making these movements by hand costs money and in most cases can be done more economically by some form of mechanical equipment.

EDITOR'S NOTE: Special acknowledgment is made to the following companies for their assistance in furnishing information on material-handling equipment: American Engr. Co., Philadelphia, Pa.; The Automatic Transportation Co., Buffalo, N. Y.; Barber-Greene Co., Aurora, Ill.; The Baker R. & L. Co., Cleveland, Ohio; The Brown Hoisting Machinery Co., Cleveland, Ohio; Clark Tructractor Co., Buchanan, Mich.; Cleveland Crane & Engr. Co., Wickliffe, Ohio; The Crescent Truck Co., Lebanon, Pa.; Cowan Truck Co., Holyoke, Mass.; Cutler-Hammer Mfg. Co., Milwaukee, Wis.; The Dow Co., Louisville, Ky.; Economy Engr. Co., Chicago, Ill.; The Elwell-Parker Elec. Co., Cleveland, Ohio; Eleveyor Industrial Truck Corp., Brooklyn, N. Y.; Sprague Hoist Division, General Electric Co., Schenectady, N. Y.; The Godfrey Conveyor Co., Elkhart, Ind.; The Jeffrey Mfg. Co., Columbus, Ohio; Industrial Works, Bay City, Mich.; The Lamson Co., Syracuse, N. Y.; Lewis-Shepard Co., Boston, Mass.; Link-Belt Co., Chicago, Ill.; Mercury Mfg. Co., Chicago, Ill.; Motorbloc Corp., Summerdale, Philadelphia, Pa.; New Jersey Foundry & Machine, New York City; Ohio Elect. & Controller Mfg. Co., Cleveland, Ohio; Pawling & Harnischeger Co., Milwaukee, Wis.; The Plimpton Lift Truck Corp., Stamford, Conn.; Shepard Electric Crane & Hoist Co., Montour Falls, N. Y.; The Silent Hoist Co., Brooklyn, N. Y.; The Stamp Electric Hoist Co., Cleveland, Ohio; Standard Conveyor Co., North St. Paul, Minn.; Stuebing Truck Co., Cincinnati, Ohio; Terminal Engr. Co., Inc., New York City; Trucson Steel Co., Youngstown, Ohio; Whiting Corp., Harvey, Ill.; Wright-Hibbard Industrial & Elec. Truck Co., Inc., Phelps, N. Y.; The Yale & Towne Mfg. Co., Stamford, Conn.; The H. Zeering Mfg. Co., Cincinnati, Ohio.

Using a belt conveyor to assemble radio parts.

Each worker does his or her task on a radio part and throws it back on to the conveyor. A special arm slides it off at the next worker who performs the next task and again throws it on the conveyor and so on down the line. When finished, inspected and boxed it is thrown into the center section which carries the box to a cross conveyor at the far side of the room. This carries the box to the storeroom.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT F. E GOODING A. J. WHITCOMB

Chicago, February, 1924

A Time and Place for Good Judgment

DETAILS of an installation have recently come to our attention which show how easy it is to make a simple job a hard one.

A pump, driven by a general-purpose motor with automatic control, was installed in a room where the temperature is unusually high. Inasmuch as the controller had barely sufficient capacity for the motor under ordinary working conditions, the high operating temperature caused overheating of the controller contactors. To correct the trouble, circuit breakers were installed immediately ahead of the controller and a knife switch was provided to shunt the controller after the motor was started. The knife switch and controller were interlocked so that neither could function at the wrong time. Shortly afterwards it was found that failure to provide a no-voltage release for the circuit breaker left the motor subject to serious injury when the power came on, after interruption of service.

This case is mentioned in order to emphasize three points. First, an adequate margin of rating is essential under varying service conditions. Second, even in simple applications such as the above, a complete analysis of service conditions should be made. Third, when a makeshift is used, care must be taken to see that it does not introduce some new element which may endanger the entire application. Many a superintendent spends nights worrying about an incorrect mechanical or electrical application that could have been prevented by proper knowledge of the service conditions.

Material, Labor and Power Service

AFTER an industrial works is built and fully equipped the elements of production are three: material, labor and power service. In the past much attention has been paid, and definite figures have been compiled, to indicate the best balance of material expenditures and labor expeditures, but it is only recently that proper attention has been directed to power service as a part of capital account and operating expense. In those cases where investigations have been made, however, some interesting revisions of what heretofore seemed a good balance of material and labor expenditures have been brought about.

Power service today in plants that are converting raw materials into finished products on a satisfactory margin of profit, includes the correct combination of electrical and mechanical drives and control at machines engaged in production operations, and moving up to and taking away of materials worked on without loss of production time by the men working on these machines. It includes the providing of light suitable in intensity to the operations performed and the speed at which the operator can work without spoilages and rejections, adequate facilities for transportation of semi-finished and finished parts between departments, from departments to stock and from stock to shipping platform, the measurement of electrical energy used and the regular checking of machine production through graphic records to maintain fair loads on machines and to catch overloads before breakdowns occur. Finally it involves the inspection and maintenance of power-operated devices to prevent clogging of the continuous flow of materials in production through the electrical or mechanical failure or faulty operation of a single unit.

To this element of production: namely, power service and its maintenance, INDUSTRIAL ENGINEER is devoted. It is already a problem of large magnitude and will grow larger and more important as industrial works expand and cover larger area, as departments are added and the volume of work in any plant is increased. It calls for a practical interpretation by you practical men and your co-operation in working out the details of best practice. INDUSTRIAL ENGINEER aims to be your handbook and your code of best practice.

Pass This Issue Around the Works

MOST new equipment originates in one or both of two ways: From suggestions of users and buyers for special equipment that can be widely used, and from ideas of designers in simplifying or improving existing equipment that can be used in new ways or will make present methods less complicated. In one case the user justifies the added first cost by the economies that are possible, and in the other the maker justifies the development and production expense by the increase in gross sales that will in a reasonable time show an added profit on the lines that are produced. No manufacturer can afford to make a device for which there is a restricted use except at a very high cost to the user, and no user can afford to purchase all apparatus designed and built to meet his special requirements. Good operating and manufacturing practice, therefore, calls for a meeting of users and manufacturers on a common ground of standardization so that the most commonly used devices will be available at prices that quantity production and wide demand make possible.

The design room, laboratories and work shop of the maker are the center where creative ideas take on usable forms while the plant and processes of the user are the test rooms where the needed improvements due to natural wear and tear, avoidable carelessness

and rough treatment from handling by men unfamiliar with the theoretical or technical features of operations come to light and call for changes and improvements that make a scientific idea of practical use. A delicate watch mechanism in a glass case free from dust and vibration performs quite differently when carried in the pocket of a workman in a cement mill, for instance. In other words, the surroundings and use of an operating mechanism determine the service that can be expected of it. So it is in industrial work; the things that are new today in principle or application represent the thinking and needs of a few, perhaps, and will become permanent and widely used through the combined efforts of all who see the economies of the future that the introduction of these new ideas will bring about.

This issue of INDUSTRIAL ENGINEER is devoted to new developments of manufacturers and the details of new applications of standard types for the benefit of users who are working along specialized lines of plant production and have the accumulated knowledge of experience that will enable them to locate the facilities and thinking on the part of manufacturers who are now in a position to take up new requirements in their particular plants or apply some existing equipment that fits a need that heretofore might have been undiscovered or waiting for some phase of the new developments that are now mentioned by the manufacturer. Such an inventory of new ideas and new equipment goes hand in hand with an inventory of wastes and deficiencies of existing equipment in industrial work, particularly in those plants where the useful life of existing equipment is practically spent. We shall make this inventory of new ideas in equipment and its application once every year and we suggest that you pass this issue around the works among those who are interested in better methods and equipment and then find a permanent place for it where it will be handy for frequent reference during the year.

When You Can't See the Forest For the Trees

EVERY JOB has connected with it more or less detail or routine work which must be thoroughly mastered if the job as a whole is to be successfully handled. Mastery of this detail work is, however, distinctly a means to an end, and not an end in itself. Failure of executives to make good in their positions can, in many instances, be traced to the fact that they did not recognize and apply the principles of this truth to their work.

When one becomes too much engrossed in the details of a job he is almost certain to lose sight of its real purpose and scope. Then the ability to do constructive work is greatly reduced. It is very easy to get so wrapped up in the methods employed in doing a job that the results are overlooked. Methods are, of course, an important element in the success or failure of an undertaking and should receive all of the attention necessary to make sure that they are adequate for the job in hand, but after all, results are what count. They are the yardstick by which the work of every one of us is measured.

It is a good idea once in a while to analyze your job and your attitude towards it. Without an occasional survey of this nature you may unconsciously get so close to your job that, as someone expressed it, "you can't see the forest for the trees."

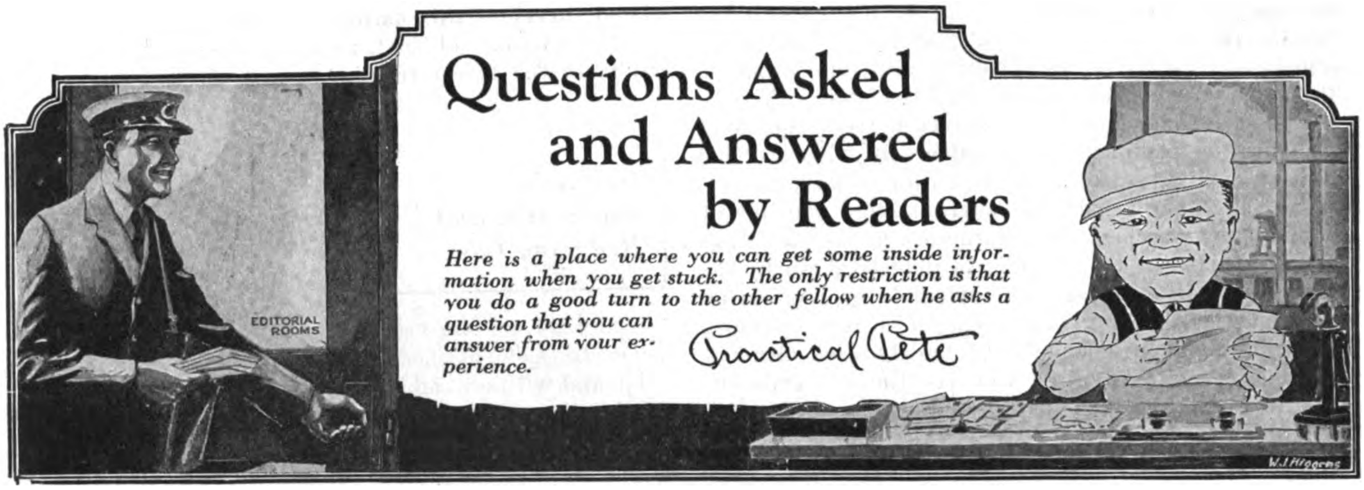
Increasing Production and Reducing Costs

THIS is an every-day and every-night problem in the minds of every plant manager and superintendent who takes his job seriously and although he may do a little better this year than last, he will never be just satisfied. A man of large vision, initiative and with an ambition to make his experience count for all it's worth, is never just satisfied. That's why he's a leader of men and is placed in that position. America is proud of these men and we have them in goodly numbers—they don't just happen, they come in most cases from the rank and file and they get to where they are by dogged persistence and that confidence in experience and ability that we all have, but sometimes fail to show, because some of us are less aggressive in our methods and don't know just how to push our ideas to proper recognition at the right time and in the right place.

But just as a cunning general is not an army and an army without a general is as uncontrollable as a mob, so in industrial work there is a place for every man when every man is in his right place. It's the finding of that place that counts just as much and perhaps more than a title and the responsibilities that go with it. For after all, results count and each and every one of us can get better and larger results in the job we now have if we spend all our time in that direction and stop worrying about the job and results of the other fellow. When you get to know him, you will find that he has his own troubles, too, and the roses that lie in his path have the same kind of thorns, that prick just as deeply as those that you run into now and then.

So when the boss talks about increasing production and decreasing cost don't think he is trying to find a way to eliminate your job or cut your salary. In ninety-nine cases out of a hundred he is inviting you to show the leadership you possess on your job and giving you the opportunity to do something that you have been waiting for. This opportunity will not come headed by a brass band—it slips up quietly and hangs around you in one form or another all the time. It's like the radio waves these days. Anyone can tune in the strong signals, but to bring in the weak signals you have to have the proper receiving equipment, a lot of patience and stay with them until all at once—in they come.

Plant managers are determined to make more money this year than last. They made enough last year to spend a little this year to still increase the net without working overtime and taking on more business than can be handled with the equipment available. If you are down where the wheels go around you are the man who knows how to get a little more out of the machines now in operation, how to prevent interruptions and breakdowns that cost money, how to improve existing methods to save time and how to stop the leak or the trouble that has happened repeatedly on a particular group of machines at the wrong time. That's your opportunity today—go to it, tune it in. You can do it if you think you can and won't give up.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Who Can Answer These?

Winding Data for Transformer of Rectifier—Can some reader of INDUSTRIAL ENGINEER tell me how many turns there are on the transformer of a 5-amp. Tungar rectifier? I dismantled my rectifier sometime ago and have lost the winding data.

Valparaiso, Ind. A. T. M.

* * * *

Simple Thermostat for Electric Oven—I should like to have some reader tell me how, and of what metal, to make a simple thermostat that can be adjusted. This thermostat will be used on an oven that will be heated to temperatures ranging from 212 deg. F. to 1,000 deg. F. and at no time will the current exceed 250 volts and 5 amp. I want to use this thermostat also for indicating by connecting it to a lamp circuit. J. G. B.

Masontown, Pa.

* * * *

Effect of Armature Coil with Reversed Polarity—Sometime ago this question was raised in our shop: Will a reversed polarity coil in an armature burn out while running, or what effect will it have on the armature?

I contend that in order to burn out a coil a heavy current must flow in that coil, which could only be caused by a short circuit. As all coils are connected in series, current of the same amount would flow in each; if one were reversed it would oppose the action of the others and having only the same amperage through it as the others it could only oppose with the strength of one coil, and would neutralize one armature coil.

I should like to hear from some of the readers of INDUSTRIAL ENGINEER on this question.

McKeesport, Pa. E. K.

* * * *

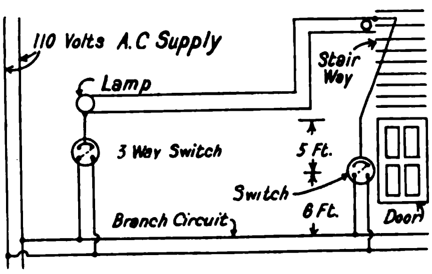
Portable Electric Grinder Lacks Power—I shall appreciate it if some of our readers will answer the following questions. I have a single-phase portable grinder which has two windings, starting and running, but the motor does not seem to have sufficient power when grinding. I should like to know if this motor could be re-connected for three-phase operation, eliminating the automatic cut-out on the rotor. The motor has twenty-four slots ⅝ in. deep and 5/16 in. wide. The iron back of the slots is ⅜ in. thick. Inside diameter of stator is 3⅛ in., length of stator 2½ in., diameter of rotor 3 1/16 in. If this change is possible, what size wire and how many turns should be used and what will the pitch be? I should like to have it operate at 3,600 r.p.m.

I have a small blower motor which operates at 220 volts direct current, and wish to change it to operate at 110 volts direct current. Will I have to reconnect the armature or should it be entirely rewound? The commutator has twenty-four bars and the armature has twelve slots.

Medina, Ohio. C. F. N.

* * * *

Protecting Wires from Mechanical Injury—How should the 5-ft. stretch of wire from floor to switch, shown in the accompanying diagram, be run for proper protection from mechanical injury? Knob and tube work is used throughout on this job, and the wire in question is to be installed in an unfinished stairway leading to a



cellar. There is no partition through which to fish the wire. Further, when the wall of the stairway is finished it is to be back-plastered; so there will be no partition even then. I shall appreciate it if some reader can tell me the best way to meet the above conditions.

Concord, Mass. D. F.

* * * *

Construction of Alternating - Current Magnet—What information can the readers of INDUSTRIAL ENGINEER give me about making a coil for an a.c. magnet to operate on 110 volts, 60 cycles? This magnet should be able to lift about 2 lb. and will be controlled by a float switch, which will open and close the circuit. I should like to know what kind of core would be best, and the amount and size of wire required. Which would be better, a long coil or a short one? I shall appreciate it very much if some reader can give me this information.

Pembroke, Ont., Can. G. B. A.

Answers Received To Questions Asked

With reference to the trouble experienced by R. I. G. with two portable electric drills, as reported in the December issue, I would suggest that he check up the following points: (1) Is the frequency of the circuit correct for the drills? (2) Are the field coils all of the proper polarity, that is, north, south, and so on? (3) Are the fields connected in series when they should be in parallel for 110 volts? (4) Has the stator shifted in the casing, thus throwing the brushes out of line? This is a very likely cause of the trouble and can be checked by moving the front bracket around a little at a time and checking the speed at each setting. Use a C clamp to hold the bracket while testing.

If the trouble cannot be located in the above manner it would probably be best to send the two drills back to the manufacturers.

Detroit, Mich. A. C. ROE.

* * * *

In answer to one of H. C.'s questions in the October issue, I am giving a quick method that I have used for removing the coils from partially - closed - slot armatures. A pry, made from a piece of pipe, has a slot cut in one end large enough to fit over the number of wires of the coil which is to be removed from the stator. After obtaining sample coils and checking the connections, all of the coils on the side where the jumpers are located are cut close to the slot with a pair of diagonal pliers. The stator is then laid flat on this side and the slot in the pry inserted in the loop of a coil. The coil may be easily pried out, using a block of wood for the heel of the pry when necessary. A stator or

armature can be stripped very easily in this manner. S. H. SAMUELS.
San Francisco, Calif.

* * * *

Trouble with Balance Coils on Lighting Circuit—I recently had trouble with a lighting circuit which was to be supplied by a 440-volt, 60-cycle generator. We wanted to get 110 volts, but the only apparatus available to make this change was two Westinghouse balance coils, built for reducing 220 volts to 110 volts. Numerous connections were tried, such as hooking up the two coils in series across one phase of the 440-volt lines, but the balance coils just would not balance the load. One circuit would receive about 150 volts, while the other would show only 85 volts.

Can anyone who has had wider experience than I in this line suggest a way to make these coils work together? Or can you tell me just why they will not work?
Smackover, Ark. W. N. T.

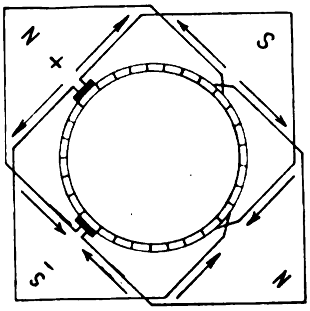
In reply to the question asked by W. N. T. in the November issue of INDUSTRIAL ENGINEER, I would say that two balancer coils as described cannot be operated in series to give balanced voltages unless the loads are balanced as to the coils and are all equal, in which case, of course, there would be no object in using the coils. The difficulty lies in the fact that you have two separate magnetic circuits. With loads on one coil and not on the other, the unloaded coil acts only as an impedance, in which case the voltage across the unloaded coil will vary according to the amount of current being drawn through it. I do not know of any way in which two such coils can be successfully used for the purpose. D. C. HERRICK.
Electrical Engineer,
National Lamp Works of G. E. Co.
Nela Park, Cleveland, Ohio.

* * * *

Path Followed by Current in D. C. Generator—I wish some reader would show by a diagram the commutator connections and the path followed by the current in a direct-current generator which has two poles, 29 segments, 15 slots and 15 coils with a winding pitch of 1 and 4. The machine has two brushes set at 90 deg. I removed a short circuit from the armature of this machine and afterwards drew a diagram to trace the current. Owing to the winding pitch I failed to get the right direction of current flow for each coil. I have had considerable experience in winding d. c. and a. c. machines but this is the first time that I have seen a machine of this design.
Libby, Mont. J. Q. W.

In the October issue of INDUSTRIAL ENGINEER J. Q. W. asks for the commutator connections and the path followed by the current in a two-pole, direct-current generator. I believe that the accompanying diagram will give him this information.

This is a wave winding and has only two current paths in parallel between brushes, regardless of the number of poles. It is necessary to use only two sets of brushes for a machine of any number of poles, although commutation is better when the number of brushes equals the number of field poles.



Path followed by current in two-pole, direct-current generator.

The wave winding is used in small and medium-sized machines where it is desired to keep the number of coils as small as possible.
Albany, Ga. B. BELCHER.

* * * *

Testing and Balancing Small Rotors—I wish some reader of INDUSTRIAL ENGINEER would tell me how to test small rotors for all defects which would cause them to run hot. Will someone also tell me what is the best way to balance a rotor?
Vincennes, Ind. R. M.

R. M. asked in a recent issue about a way to test and balance small rotors. We test small wound rotors for shorts with a growler and piece of tin. For opens and grounds we use a test lamp. If the rotor has both starting and running coils, the leads for these windings must be separated when testing for opens and grounds.

For balancing the small rotors we use two steel rules or scales set up on edge in two wooden blocks and put the bearings of the rotor on the edges of the scales. The heavy side of the rotor always goes to the bottom. Small weights can then be added to the light side, to balance the rotor. GEORGE RINGNESS.
Peoria, Ill.

* * * *

In answer to R. M. in a recent issue, about testing small rotors for defects that will cause them to run hot, very common causes of trouble are an overload, loose rotor bars, worn bearings, and, in some cases, too low or too high frequency, or too low or too high voltage.

To test for loose bars, tap each bar with a small hammer and notice if there is a difference in the sound obtained from some of the bars. If the rotor is in good condition it will sound the same all around. Another way is to put the motor in a dark place, start it and when it is up to speed reverse the direction of rotation quickly. This will cause an excessive amount of current in the rotor and if any bars are loose sparks will be seen inside the motor.

If the rotor is not in proper condition have the bars welded, or resoldered, if it is a fractional-horsepower motor. In case of an overload remove load until the motor is working at its horsepower rating.

To balance a rotor put it on balancing wheels; see that the shaft is perfectly smooth and that there is no dust or dirt on the shaft or wheels. Give it a little start and when it comes to rest the heavy side will, if the rotor is out of balance, be at the bottom. Put metal on the top or light part of the rotor until it will stay in any position in which it is placed. P. P. SCRIBAUTE.
San Francisco, Calif.

* * * *

In the question by R. M. in a late issue, I presume that he refers to induction motor rotors. The cause of such a rotor running hot may be due to several things and may not be the fault of the rotor at all. Core loss is one of the main factors and is serious on small motors where the air gap is very small and where proper precautions are not taken in the design of the stator core or stator teeth. It is for this reason that good makes of such motors have what is called closed slots, or on larger sizes magnetic bridges are used so that the magnetic flux as it enters the rotor is spread out more uniformly. The rotor core should be laminated and all electrical contacts between rotor bars and end rings should be good. If the rotor winding is defective the machine will have an uneven torque which will be noticed at starting by the motor not pulling the load or by the uneven hum of the machine as it speeds up. Such defects in the rotor winding can easily be detected by applying a low voltage to the stator and noticing the current on an ammeter while the rotor is slowly turned around by hand. If the rotor winding is not uniform, due to unsoldered or broken bars, the current in the stator will vary considerably as the defective bars pass under the poles. For such a test single-phase or polyphase current can be used, but the ammeter need be placed in

only one phase. Any voltage that will give a good reading is all right.

To R. M.'s last question, I would say that the rail method of balancing is by far the easiest for all ordinary rotors and if care is taken it is quite satisfactory for ordinary-speed machines. The main fault with rail balancing is that it does not indicate on which end of the rotor to place the weight, which is important for very good balance. When a rotor so balanced does not show up good on running, it should be placed in a lathe and carefully watched for such defects as a crooked core or other lack of uniformity in such parts as the end rings or flanges. If such defects are noticed they must either be removed or weights added to counterbalance them.

PHILIP G. BERNHOLZ.
East Orange, N. J.

* * * *

In his question in a recent issue, R. M. does not say whether he is referring to wound or squirrel-cage rotors. Wound rotors will heat from overload, worn bearings, loose connections in the commutator and a loose or dirty short-circuiting ring. Squirrel-cage rotors will heat from overload, worn bearings, and loose connections of bars in the end rings. Low voltage will cause both types of rotor to heat.

When balancing small rotors I find out, by any of the usual methods, which is the heavy side and then fasten on the opposite side enough small pieces of brass to balance the two sides. Another method which I have sometimes used is to drill small holes on the underside of the bars on the heavy side of the rotor.

Albany, Ga. B. BELCHER.

* * * *

In answer to the question by R. M., in a late issue, we presume that he is referring to squirrel-cage rotors used in induction motors. We find that many of the older type rotors run hot and do not pull their load, due to some of the bars coming loose from the short-circuiting end rings. Sometimes this condition is not visible and the rotor is apparently in good condition. Our method of locating this fault in the case of a two-phase or three-phase motor is to pass a single-phase current of about half-voltage through one phase of the stator winding with an ammeter connected in series. The ammeter will show a reading and by turning the rotor over by hand very slowly the reading will be constant in the case of a good rotor, but will fluctuate with a rotor which has open circuits in the bars. We use acetylene welding to repair rotors with loose bars as this makes a permanent repair job. In the case of split-phase motors the starting winding should be disconnected from the circuit when the ammeter test mentioned above is made.

KOONTZ BROS. ELECTRIC CO.
South Bend, Ind.

* * * *

How Do You Explain Operation of Variable-Speed Induction Motor?—I would like some help from readers of INDUSTRIAL ENGINEER on the following questions: (1) In a variable-speed induction motor how does the rotor cut down the speed when the field is revolving at full frequency speed? Please explain briefly the theory. (2) Why are the slots in a Westinghouse 30-hp. rotor on a considerable slant instead of straight across and parallel to the shaft?
Chicago, Ill. V. L.

In a recent issue, V. L. asked, (1), how a variable-speed induction motor operates. A brief explanation of the principle of the induction motor will help to make this subject clear. It is understood that the revolving field set up in the stator or primary winding induces an electromotive force in the secondary or rotor winding and that the current flowing in the rotor circuit depends upon the rotor circuit resistance disregarding the rotor counter e.m.f.

At no-load the rotor will run at nearly the same speed as the field, the frequency of the rotor magnetism will be practically zero and there will be very little torque developed. When a load is put on the motor the speed of the rotor in r.p.m. falls, thus causing a slip or difference between the speed of the field and the rotor. This slip increases the frequency of the rotor circuit; this in turn increases the e.m.f. of the rotor thus causing more current to flow in the rotor, which in turn produces enough torque to pull the applied load. This process would continue until the pull-out torque of the motor is reached. In the above example it was the applied load that caused the speed to drop. The drop in speed runs 3 to 7½ per cent.

From the above it follows that the resistance of the rotor limits the amount of current; that the e.m.f. necessary to force this current through the rotor depends upon the frequency of the rotor magnetism and that the speed is susceptible to a change in the rotor resistance. Take the case of a slip-ring motor working against a constant torque. If resistance is inserted in the rotor circuit a higher e.m.f. in the rotor is necessary to force the required current through to keep the torque constant, the rotor drops off in speed, thus increasing its frequency and its e.m.f. If the slip at a given torque and rotor resistance is 15 per cent, then the slip will be 30 per cent if the resistance of the rotor circuit is doubled. Therefore, increasing the resistance of the rotor circuit decreases the speed and decreasing the resistance increases the speed. This change in speed is brought about by transformer action between the primary and rotor.

(2) The slots of induction motor rotors are skewed or slanted to prevent dead spots. In some of the old motors where the ratio of stator to rotor teeth was not within certain limits there were dead spots; that is, when the rotor stopped in certain positions it could not be started again without turning it slightly.

Detroit, Mich. A. C. ROE.

* * * *

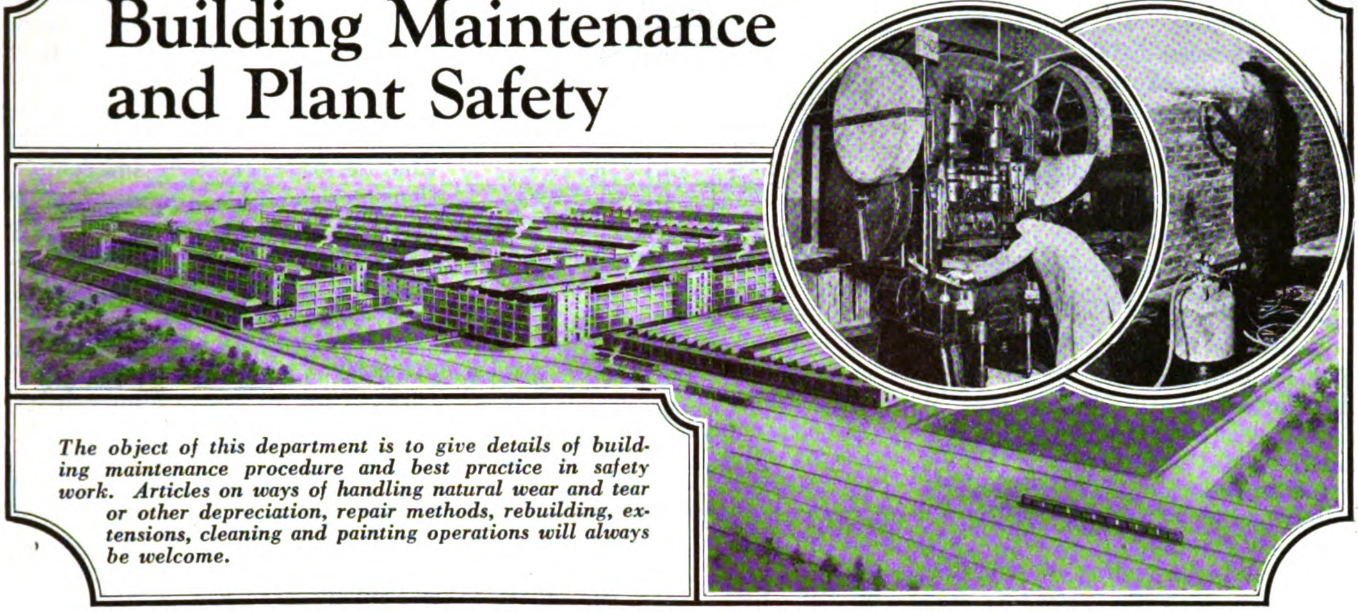
Preventing Corrosion of Iron Storage Battery Racks—I should like to ask your readers what treatment can be given to iron racks for storage batteries which will prevent the spilled acid from attacking the iron. We use the lead type of battery filled with dilute sulphuric acid. We have a large number of storage batteries and recently some iron racks have been constructed. All of these racks were painted with several coats of the best grade of asphaltum black paint but this does not protect the iron when acid is spilled on it, nor does any kind of paint that I have tried.

We have had considerable trouble due to the corrosive effect of the acid forming a substance resembling sand which falls into the jars below. This produces excessive iron in the solution, making a change of acid necessary. I shall appreciate it if anyone can tell me how to overcome this.
Atlanta, Ga. J. B.

Referring to the question by J. B. in a recent issue, there is on the market a protective medium known as Gardco which is very resistant to the action of acids, acid fumes and brine. In direct tests it has been subjected for hours to steam and the fumes of muriatic and nitric acids and was only slightly affected. I have had on my desk for more than two hours a sheet of tin covered with this product on which there were placed three drops of sulphuric concentrates and it showed hardly any effect. I believe it would be worth while for J. B. to try out this product and he can satisfy himself very quickly through his own tests whether or not it will solve his problem.

IRA D. LOCKWOOD.
Buffalo, N. Y.

Building Maintenance and Plant Safety



The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

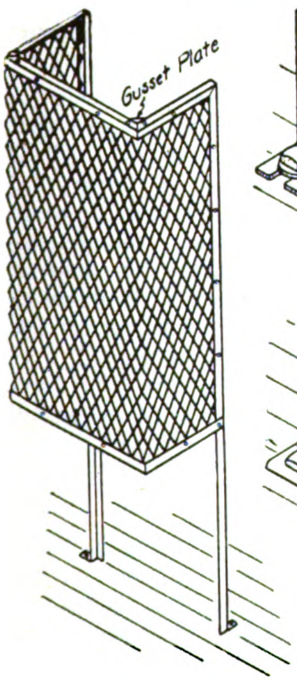
Easy Method of Building Machine Belt Guards to Fit Conditions

PRACTICALLY every machine must have some form of guard around an open belt. These requirements are specified by the insurance companies and by the state factory inspection bureaus. Because of the wide variation in sizes and angle of inclination of belts, it is frequently difficult to purchase guards ready made for all locations, and so it is common practice in a large number of industrial plants to make the guard to fit conditions. One common method is to use sheets of expanded metal (North Western Expanded Metal Co., Chicago, Ill.) which are held together by angle-irons. How this may be done is shown in the two accompanying sketches. Both of the guards shown are common types and well indicate the possibilities.

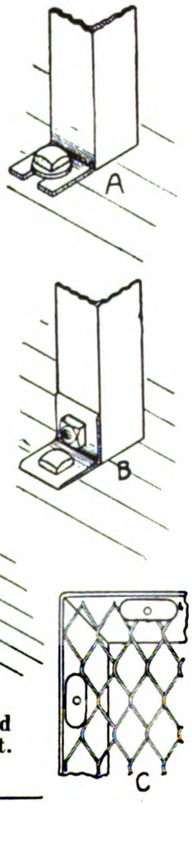
When making guards for vertical and inclined belts, one side of the belt is frequently protected by the frame of the machine and so a three-sided guard is all that is necessary. Ordinarily, when three-sided guards are used, and the oil holes are inside the guard, it is necessary to provide a door. The common practice is to have the guard attached to the floor and to the machine frame with bolts or thumb screws. In such cases where it is necessary to get at the pulley or belt for repairs, the complete guard can be easily removed.

In case a four-sided guard is used, it is usually necessary to provide one removable side or door. The door as shown in the accompanying illustration is but little more expensive than the removable side and generally is recommended. Short-length doors are recommended as they are stronger and brace the guard more easily than is possible with a full-length door. If the whole side is removable, the edge of the expanded metal is fastened by U-edging and bolted to the frame work of the guard. Doors are also made with U-edging and hinged to the angle-iron framework.

For ordinary work, the expanded metal sections after being trimmed to size and shape by a chisel or a shear, are fastened to the angle-iron framework by bolts and small plates as shown in *C* of the accompanying illustrations. Two methods of fastening the frame work to the floor are also shown. These expanded metal sheets are made up of 18 or 13 gage sheet with a diamond opening 1¼ in., 2½ in., 4 in. or 6 in. long. The sheets come in standard sizes about 4 ft. by 8 ft. or 6 ft. by 8 ft. These may be cut into any



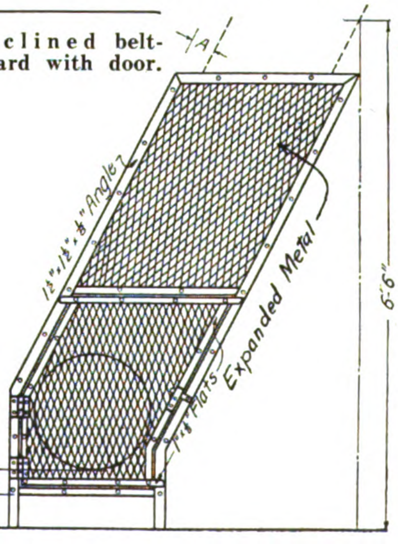
A three-sided guard for a vertical belt.



These sketches show how guards may be built up for belts.

After the expanded metal is cut to shape, the edges are fastened together by angle-irons, which also act as a framework to support the entire construction. The sketches show the construction of both the vertical and the inclined guard. Care must be used in constructing inclined belt guards so that ample clearance is allowed for the flap of the belt on the loose side.

Inclined belt-guard with door.



shape and fastened together with angle-irons so as to fit practically any conditions. In plants where these expanded-metal guards are made up to fit the job quantities of these sheets, angle-irons and U-edgings are kept on hand and cut according to specifications for any particular guard.

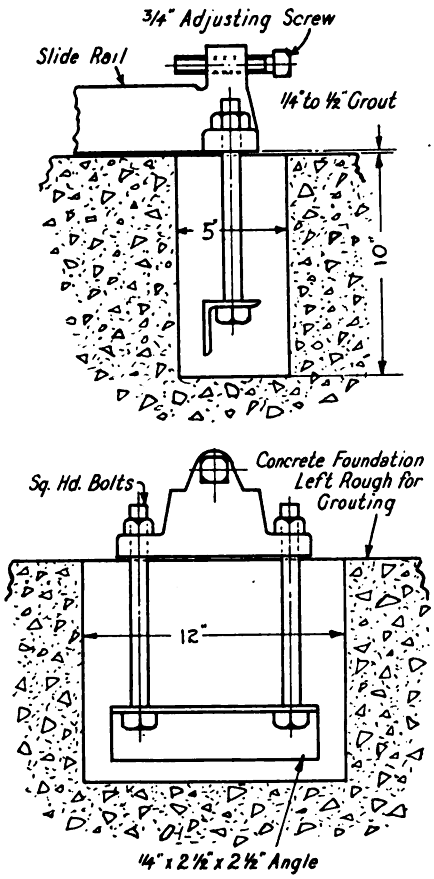
Simple Method of Installing Anchor Bolts for Bedplates and Machines

IT IS comparatively difficult and impracticable to place or set anchor bolts rigidly in concrete foundations accurately to fit the corresponding holes in slide bases, bedplates, and electrical apparatus. To overcome the many difficulties encountered in providing a concrete foundation with the necessary anchor bolts accurately placed for any equipment, the following method has been found very satisfactory, economical, and practical.

The layout of the anchor-bolt holes is obtained from a blueprint or measured directly on the apparatus to be installed. The centers are laid out on the foundation, and a square hole chipped out, the size and depth depending upon the size of bolts used. If a new foundation is to be built the holes can be provided for by setting square or rectangular forms in the desired location when pouring the concrete foundations.

The illustration below shows a cross section of a foundation and indicates the method of placing the anchor bolts in the bedplate of a printing-press drive equipment. The 10-in. square by 8-in. deep holes are provided at the time the foundations are made and are used for a 1¼-in. anchor bolt. The printing-press drive is placed on the concrete foundation about ¾ in. to 1 in. above the rough concrete surface and is accurately aligned and leveled by means of the elevating screws *A*.

The anchor bolts are put in place in the bedplate lugs and suspended in the hole as indicated. When the equipment has been leveled, a box-like frame is built around it which is filled, together with the anchor bolt holes, to about 1 in. above the bottom of the bedplate with a mixture consisting of cement with one or two parts of sand. After 24 hr. the wooden frame can be removed and in three to six days later the equipment may be put into service.



One method of installing anchor bolts.

A rectangular hole, large enough to take the two anchor bolts is left in the foundation. The heads of the bolts are prevented from turning by the strip of angle iron. After the rail is carefully placed and lined up the rectangular opening is filled with cement. Sufficient space is left for grouting.

Another method of anchoring slide rails or bases for motors is to use a standard bolt with a piece of angle-iron as an anchor and also to prevent the bolt head from turning. This can be set in the foundation or in a box opening and grouted in afterward. The two sketches above show how a slide-rail for a motor or other machine may be set by this method.

The magazine paper reels as used for feeding newspaper printing presses, installed underneath the presses on concrete foundations, were installed by the above method. The anchor-bolt holes were all laid out from the blueprint plan and the anchor-bolt holes provided at the time the basement floor and foundations were poured. These reels must be accurately aligned with press parts and level, which was easily accomplished because of the variation permissible in the shifting of the anchor bolt before grouting in permanently.

In a test a ⅝-in. standard bolt with a 3-in. diameter standard bevel cast-iron washer was grouted in a hole 4-in. square and 6 in. deep with a 1 to 2 mixture. After several months when the grout and the surrounding concrete foundation had thoroughly hardened, a 20-ton jack was attached by means of chains to the extending end of the ⅝-in. bolt with two nuts locked together to hold the chain. The pull on the bolt was applied gradually with the result that the threads stripped, but the bolt was not withdrawn from its position, nor did it break out the foundation. In this case the concrete foundation was 12-in. thick and made of a 1-2-4 mixture.

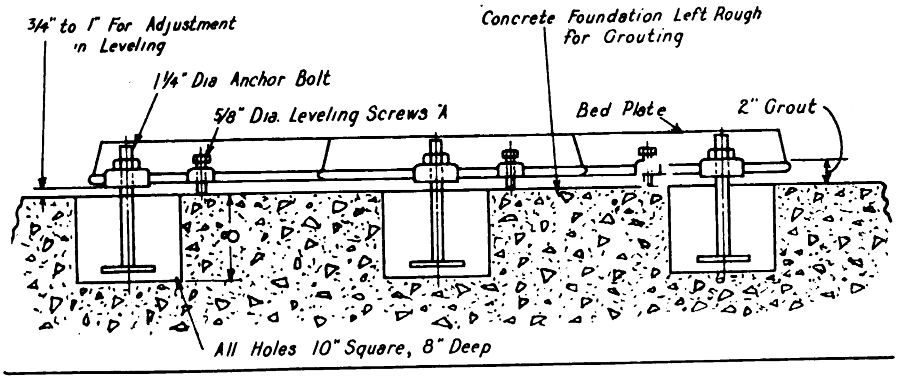
E. H. LAABS.

Engineer, Printing Equipment Dept.,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

Easy Method of Increasing Service of Wooden Floors Between Renewals

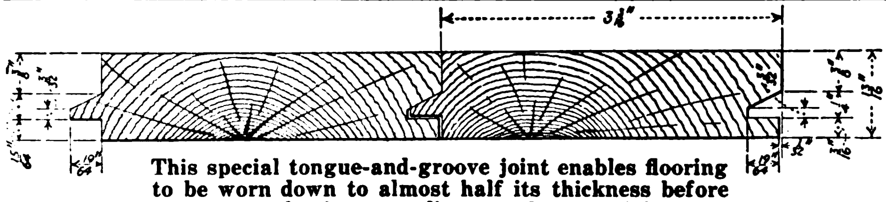
FACTORY floors, if made of wood, wear unevenly where they receive the heaviest traffic, such as that from trucking or from men stepping on or off elevators or other places. The ordinary tongue-and-groove flooring starts to splinter when the board has worn down to about one-third of its thickness and begins to expose the groove.

Industrial plants which have trouble such as this may use to ad-



How a bedplate for a printing-press paper-reel was set.

This must be set very accurately. The sketch shows how the anchoring was done and the ample provision for adjustment. This method of placing anchor bolts has been used satisfactorily on a variety of equipment.



This special tongue-and-groove joint enables flooring to be worn down to almost half its thickness before the groove begins to splinter and renewal becomes necessary.

vantage the plan adopted by a street car company for platforms to meet a similar difficulty. These floors had been made of 13/16-in. hard maple boards 3¼ in. wide and it had often been found necessary to renew the flooring because of the wearing down to the groove, even though it still had sufficient strength. Finally, the special tongue and groove shown in the accompanying sketch was adopted. This enables the floor to be worn down to almost half its thickness before the groove becomes so thin as to be likely to splinter or the crack to open up. Industrial plants using this flooring for heavy trucking would probably use a thicker board but could get more wear by off-setting the tongue-and-groove.

What Wasted Air, Steam, Water, Gas and Light Cost Per Month

ONE of the most important and profitable parts of plant maintenance lies in stopping the wastes due to the miscellaneous little leaks. A hissing flow of air or steam or even a dripping of water from a poor joint or worn-out packing in a valve or faucet costs money. Because but few men engaged in this work realize the value of these losses it may be well to look over the accompanying table which appeared in "The Studebaker Co-Operator" to show the workers of The Studebaker Corporation how these seemingly trifling losses mount up, if neglected for a month.

Water, air, steam, gas and electricity all cost money. A number of little leaks can easily in the aggregate, amount to the equivalent of a large leak; so it is not always necessary to have a half-inch opening to make the loss equivalent to many times the cost of repair. Some of this loss is no doubt due to carelessness, but much of it is due to a lack of appreciation of what it means to avoid waste even though it may be small. Economy comes from many little savings more often than from a few big ones because if the little ones are passed up, there is less likelihood of the larger savings being recognized and taken advantage of.

Chicago, Ill. E. D. F.

Proper Maintenance Stops These Wasting Leaks and Saves These Losses

Size of Opening	Air		Steam		Water		Gas		Electricity		
	Number of cu. ft. wasted per month 100 lbs. pressure	Total cost of waste per month @ 10c per M cu. ft.	Number of lb. wasted per month 100 lb. pressure	Total cost of waste per month @ $1.00 per M. lb.	Number of gal. wasted per month 40 lb. pressure	Total cost of waste per month @ 9½c per M. gal.	Number of cu. ft. wasted per month 4 in. water col. pres.	Total cost of waste per month @ $1.00 per M. cu. ft.	Number of 350-watt Cooper-Hewitt lamps left burning.	Number of kw.-hr. wasted per month.	Total cost of waste per month
½ in.	17,800,000	$1,780.00	805,500	$805.50	1,250,000	$118.75	141 0	$141.00	25	6300	$142.50
⅜ in.	9,980,000	998.00	462,000	462.00	692,700	65.81	79,100	79.10	20	5040	114.00
¼ in.	4,450,000	445.00	203,500	203 .50	308,000	29.26	35,300	35.30	15	3780	83.50
⅛ in.	1,114,800	111.48	56,000	56.00	77,000	7.42	8,850	8.85	10	2520	57.00
1/16 in.	278,700	27.87	13,000	13.00	19,500	1.85	2,210	2.21	5	1260	28.50
1/32 in.	69,850	6.99	3,200	3.20	4,900	.47	553	.55	1	252	5.70

Liberal Use of White Paint Helps to Keep the Plant Clean

SOME plants, particularly those in the food industry, paint the equipment white, as well as the walls and ceiling, because white shows dirt so plainly that there is no excuse to overlook it. This same plan was also used in the glue room of another plant, where the manager took pride in good industrial housekeeping. As a result the whole room was painted white. Now when any glue is spilled it shows up so conspicuously that it is immediately wiped off before it dries and becomes too hard to loosen.

Red Card Indicates That Used Extinguisher Needs Refilling

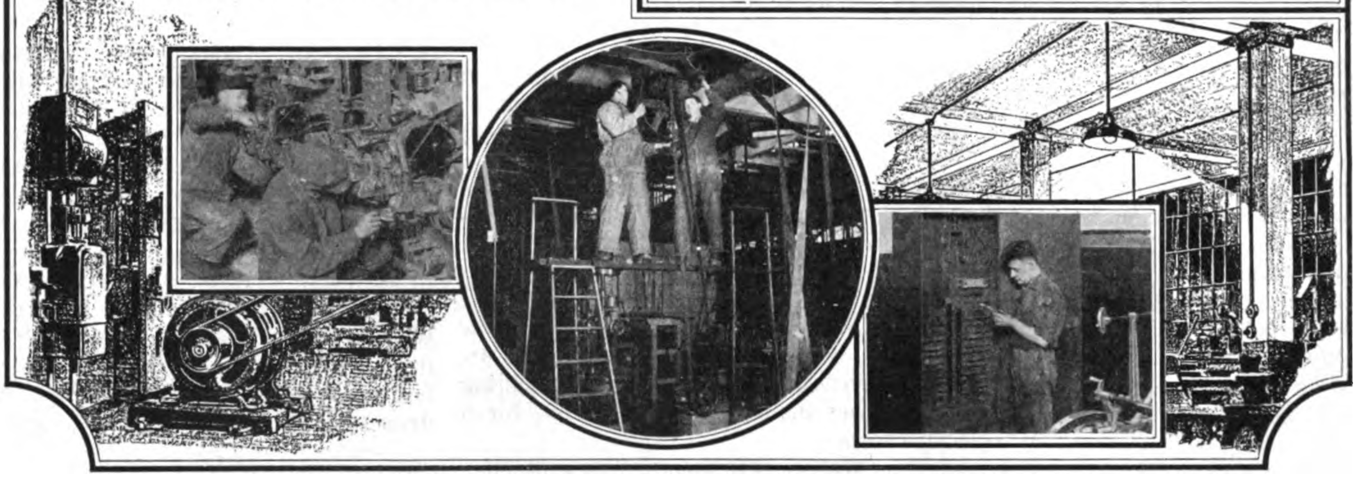
IN THE excitement incidental to a fire drill or the use of a portable fire extinguisher, the latter is often put back into place without being refilled. A practical way to indicate the need of refilling a used extinguisher is to have a strong yellow or white envelope, which has printed on the outside, "When Used Withdraw Red Card," wired to handle. The red card within the envelope is also attached by a strong cord or wire to the extinguisher. With the red card in view, the foreman of that department will notice it and promptly report it to the maintenance foreman, particularly if he is held responsible should the extinguisher be found empty. When the extinguisher is re-filled the red card is again inserted in the envelope.

It is a good plan to make a test of fire-fighting equipment and personnel about once every two weeks, by having an alarm sent in from a different location each time. In addition, it is well to have the electric pump operate at full speed, the hose run out, the extinguishers brought out and tarpaulins transported to the scene. Have at least one extinguisher play on the "fire." It is also well to work a chemical hose cart for a few minutes. When the fire is out, it is well to have the bell system or whistle sounded once or twice to indicate to the foremen that the firemen, who have responded from various departments are now ready to return to their work. H. S. RICH.

New Britain, Conn.

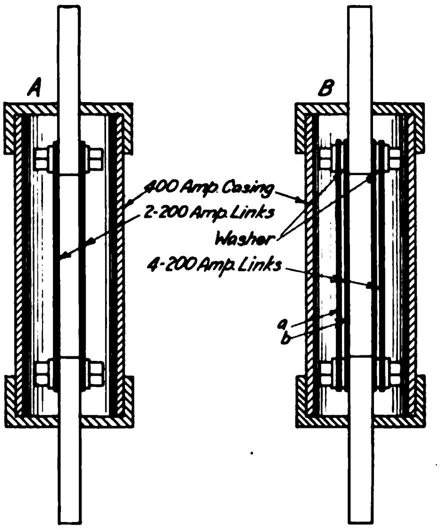
SERVICE
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Improper Alteration of Renewable Fuses Causes Trouble

A LARGE manufacturing plant was periodically closed down due to a failure in the power supply through the blowing of a set of renewable fuses. The length of the shutdown depended on the length of time required to replace the damaged links. These shutdowns cost about $400 in wages of idle men, with a loss of production that could not be accurately determined. A rough estimate would be $2,000 loss for each shutdown. At one time there were four shutdowns in six weeks.



Proper and improper method of increasing capacity of renewable fuses.

In *A* two 200-amp. links are used to make a 400-amp. fuse. As shown in *B* two extra 200-amp. links were used to increase the capacity to 800 amp., but it was found that this combination would carry only about 600 amp., as the temperature of the links was higher than normal.

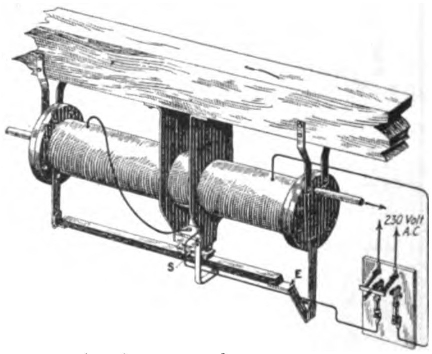
Naturally, the manufacturer first blamed the power company. The result was that the engineers of both companies involved finally made a concerted effort to find the cause of the trouble. At first the belt on a 200-hp. synchronous motor was blamed, but after a careful investigation this possible cause was eliminated. Then underground-cable disturbances were looked for without any definite results. At length, the set of renewable fuses was examined and the cause of the difficulty found. The fuse casing was designed for 400 amp., and with the addition of two extra fusible links an 800-amp. circuit was apparently protected. In reality, however, such an arrangement gives only about 600-amp. capacity. The illustrations show the correct method of inserting the links and the incorrect way of raising the capacity by adding extra links.

In Fig. *A* the heat in the link has ample space to radiate in all directions, but in Fig. *B* the two links, *a* and *b*, are so close together that their temperature rises unduly, due to the fact that the heat does not escape fast enough. Of course, 800-amp. fuses should have been used in the first place but electricians are sometimes prone to alter an existing fuse rather than put in larger fuse blocks. As a solution of the difficulty the fuses were replaced by copper bars and the incoming circuit breaker was adjusted to open in time to protect the equipment against any serious overload.

New Haven, Conn. HERBERT J. WOLF.

Construction of Simple Electric Water Heater for Shop Use

TO FURNISH hot water for washing purposes, an electric heater which has given good service was recently made in the shop of an industrial plant. A piece of 6-in. pipe, 6 ft. long, was flanged at each end and after two outside plates were bolted to these flanges, the pipe was insulated with two layers of scrap mica shellacked on, followed by a layer of asbestos tape. After this 360 turns of No. 11 asbestos-covered wire were wound on the pipe, leaving about 1/8 in. between turns. After winding the ends were tied down with asbestos tape and brought back about 6 in., to prevent any mechanical strain on the winding. The winding was then plastered over with a mixture of fire clay containing a small amount of finely-broken magnesia pipe covering. This coating was wrapped with



A 6-ft. length of 6-in. pipe was wound with asbestos-covered wire. Overheating is prevented by utilizing the expansion of the pipe to open the switch at S and break the circuit.

another layer of 4-in. asbestos tape.

To prevent damage in case the power switch should be left on, the expansion of the drum was utilized to open the circuit. An oil-treated, 1½-in. by 2-in. maple bar was hinged at one end to the drum as shown in the illustration. One end of the bar was fitted with a steel plate which rests on an adjustable steel edge, *E*, supported from the end of the pipe. A copper plate, *S*, was attached to the bar. Above it is a small insulating base with two spring contacts which touch the copper plate on the bar. When the bar is held up the circuit is completed through this plate. When the drum expands the bar drops and breaks the circuit. A stop is provided, as shown, to prevent the bar from dropping too far.

This switch acts only as a safety valve and not as an energy saver. It was found that because of the hot water rising to the top the drum tends to bend, and so the linear expansion is much smaller than was expected, although it is sufficient to operate this safety device. A test made on the heater before it was installed showed that on a 220-volt circuit it heated water from 70 deg. F. to boiling in about 30 minutes. The efficiency was found to be approximately 83 per cent, and the power factor 94.7 per cent.

New York, N. Y. EUSTACE C. SOARES.

Two Schemes for Controlling Lights from Two Points

WHEN it is required to install lights to be controlled from two different locations, they may be connected as shown in Figs. 1 and 2.

A case recently came to the writer's attention in which it was necessary to wire some garages for lights to be controlled from the residence and in the garage, and in addition have current available at all times for a heater, portable tools, extension lights, etc. In this case it was found preferable to wire the lights as shown in Fig. 2, as it permitted connecting the above mentioned accessories across lines L_1 and L_2.

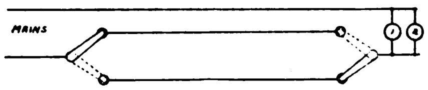


Fig. 1—Connections for three-way switches for controlling lights from two points.

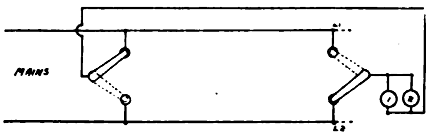


Fig. 2—A scheme for controlling lights and other socket devices by use of three-way switches.

This made current available at all times, regardless of whether the lamps 1 and 2 were lighted or not, whereas with the connections arranged as shown in Fig. 1 this could not be done. P. JUSTUS.

Superintendent, Electrical Dept., Chandler Motor Car Co., Cleveland, Ohio.

Method of Installing Ball and Roller Bearings

IN THE application of ball and roller bearings to motors, the service given by the bearings depends, (1) on the proper selection of the bearings, (2) on the right kind of lubricant properly applied and (3) on the care with which the bearing is installed. The best bearing can be spoiled by careless handling or by improper installation.

The press fit allowance for mounting bearings on the shaft varies from about 0.0010 in. to 0.0015 in. for sizes of shaft between 2 in. and 4 in., and for other sizes in proportion.

A ball bearing should be pressed on by applying pressure to the inner race only; in no case should a hammer be used directly on the bearing. The damage done by a hammer may not be noticed at the time, but the life of the bearing may be cut down 50 per cent.

The accompanying illustration shows a method which I have found satisfactory for pressing on or removing ball bearings from motor shafts. As will be seen at *A*, a hole ¾ in. or 1 in. deep is bored in the center of the shaft and tapped for a stud or bolt a foot long. This bolt is threaded the full length and the end is squared so that it can be screwed into or out of the end of the shaft with a wrench.

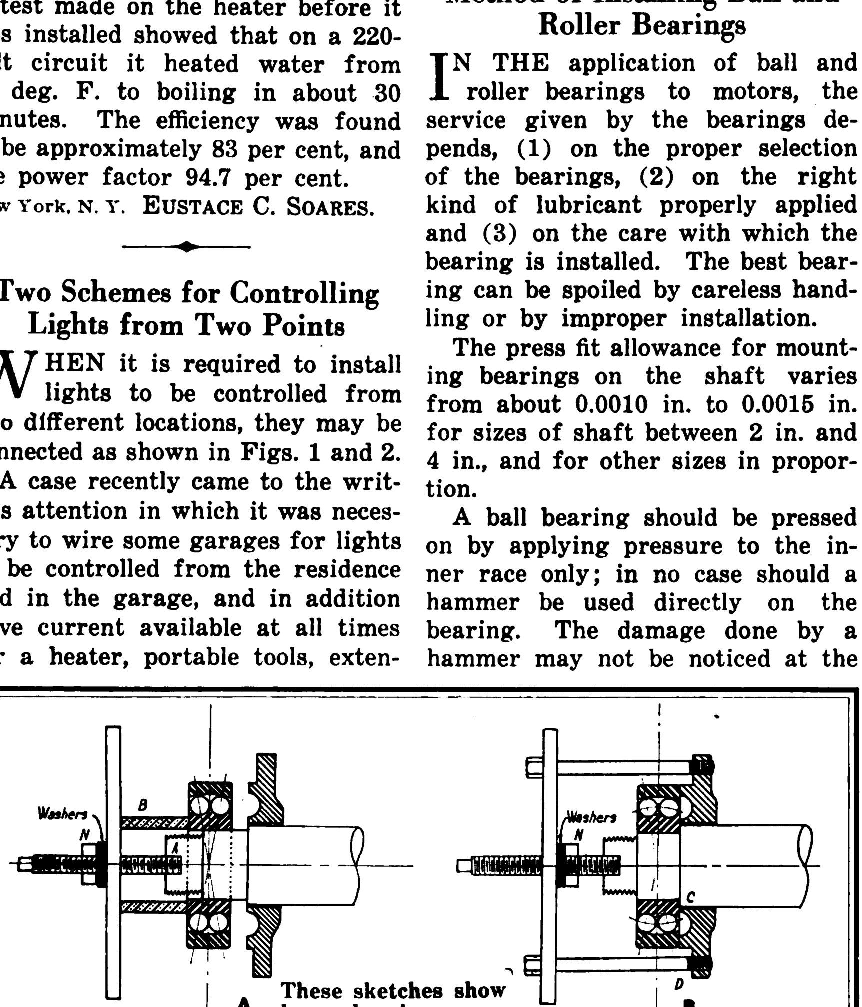
To press on the bearing a brass cylinder or sleeve, *B*, about 4 in. long is used; the inside diameter of this cylinder must be a little larger than the inside of the bearing. A bar of flat iron 1 in. thick and 4 in. wide is bored so that it will slide freely over the threaded bolt. The brass cylinder is first placed against the inner race of the bearing; the flat iron bar is then held against the cylinder and three or four washers coated with grease or vaseline are put on the bolt next to the iron bar. A nut is then screwed on to press against the washers, the bar and the cylinder. If the shaft has been turned to the right diameter the bearing can thus be easily pressed on by using a 12-in. wrench.

The washers are used to prevent the friction of the nut from turning the flat iron bar and possibly displacing the brass cylinder, which must press evenly all around on the end of the inner race.

To press on the pulley-end bearing a piece of iron pipe can be used between the flat iron bar and the cylinder. To use this device for removing a bearing from the shaft, the inner end-cap must be designed as shown at *C* and *D*, in *B*, so that the projecting lips of the end-cap can bear on both the inner and the outer race of the bearing at the same time. Preferably inner lip *C* should be a few thousandths of an inch longer, so as to bear harder against the inner race.

In the case of a spherically shaped outer race such as is used in the SKF ball and roller bearings, pressure applied against the outer race only would produce a powerful wedging action between the outer race and the balls and thus tend to break the outer race, and also to scratch the highly polished surface of the balls, thus shortening the life of the bearing.

To remove a bearing, holes are bored in the flat iron bar the same distance apart as the holes for the



These sketches show how bearings are forced on or removed

bolts holding the end-caps together when the bearing is in and the end-caps in place. In this case the nut *N* is first screwed on to the bolt; then the washers are put on, followed by the iron bar. Bolts of the proper length are run through the holes in the iron bar and threaded into the end-cap as shown. The bearing can then be taken out by turning nut *N*.

Holes of the depth and diameter required for the threaded bolt will not weaken the shaft, as the inside of a shaft carries very little load. The threaded bolt that screws in the shaft may vary in diameter from ¾ in. for a 2-in. bearing to 1 in. for a 4-in. bearing, and so on in proportion to the size of the bearing.

Belleville, Ont., Can. J. H. GALLANT.

How to Connect Transformers for Paralleling 2-and 3-Phase Circuits

A PROBLEM which often arises in changing over an old to a new system of distribution is that of tying together two-phase and three-phase systems. Although the number of two-phase systems in operation is gradually becoming less, it is sometimes necessary to operate together parts of the same system which are different. The particular case described here is somewhat special but may be of interest to those who are compelled to harmonize the operation of two- and three-phase systems.

The general outline of the conditions is as follows: A three-phase 33,000-volt circuit has connected to it two transformer substations *X* and *Y*. At station *X* the voltage is stepped down to a 4,000-volt three-phase, star-connected system. At station *Y* the voltage is stepped down to 2,300 volts two-phase by means of "T" or Scott connections. From station *Y* a two-phase circuit is carried to station Z where the voltage is stepped up to 4,000 volts three-phase.

It is desired to tie together the two three-phase, 4,000-volt circuits. There is danger, however, of making the connections incorrectly so that these two systems cannot be paralleled. The secret is in the method of connecting the transformers in station *Y*. Circuit *I, II, III* must be connected with circuit *IV, V, VI* at junction point *W*, as shown in the drawing.

Fig. 1 shows the actual physical connections for each transformer and might be considered as a practical operating diagram. The ends of the transformer windings have been lettered so that identification of the connections may be complete. Fig. 2 shows the voltage vectors for the various transformer groups as well as the combined vectors at the junction point *W*.

The important point in the connections is that the "teaser" transformer *F* at station *Z* occupies the same relative position as the main transformer *D* in station *Y*. This insures that the vectors of the three-phase voltage are in the position shown by the small triangle to the right of station *Z*. This triangle corresponds to the small triangle to the left of station *X* which shows the position of the voltages generated by the star winding. These triangles it will be noted are rotated 30 deg. from the triangle at the right of station *Y*.

The actual tests required to assure the correctness of the connections can be made with the greatest certainty through voltmeter readings taken through potential transformers connected to the respective circuits and the voltages balanced against each by interconnecting the low-voltage windings of the potential transformers used.

The practical method of testing out the connections would be as follows: At either station *X* or *Z*, or at junction *W*, provide two potential transformers and a voltmeter reading at least double the voltage of the low side of the potential transformer. Through temporary connections readings should be taken of all voltages *I-II, I-III, II-III* and IV-V, IV-VI, V-VI, to be assured that approximately balanced voltages exist in each circuit. Then test as follows: Connect at random, say line *I* to line *VI*. Readings taken between lines *III* and *V* or lines *III* and *IV* with the potential transformers in series

Three-phase and two-phase circuits connected to operate in parallel.

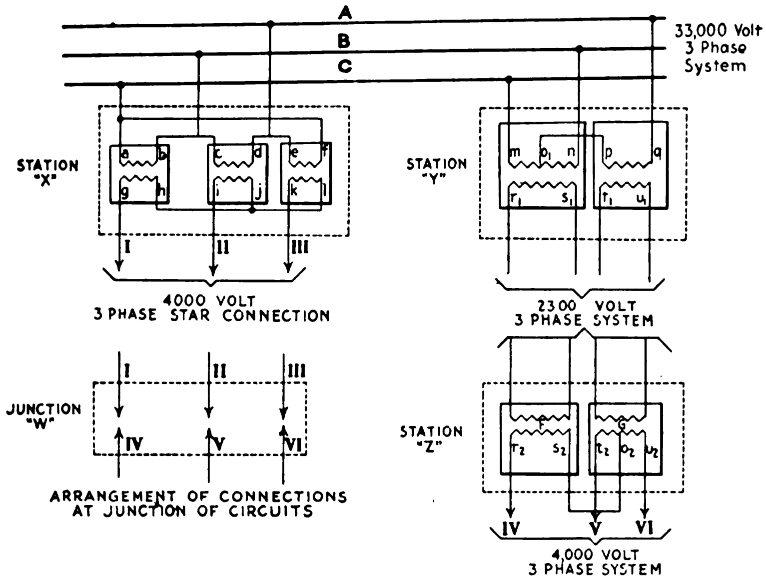


FIG. I CONNECTION DIAGRAMS

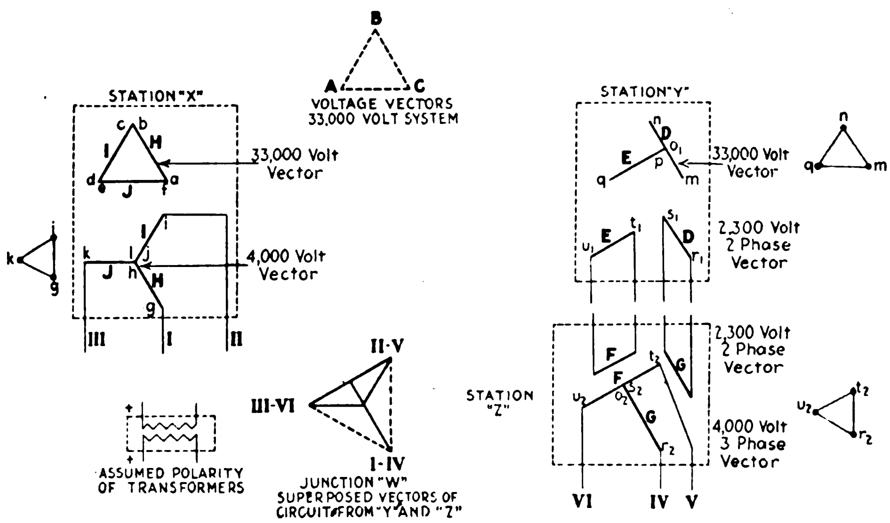


FIG. 2 VECTORS OF VOLTAGES

on the high-voltage and low-voltage sides will show a high reading on the voltmeter. The same will be true, of course, if readings are taken from *II* to *V* and *II* to *IV*. If, however, line *IV* is connected temporarily to line *I* a test between *III* and *V* will show normal voltage, but a test between *III* and *VI* will show practically zero voltage. A further check will be to test between *II* and *V* for zero voltage. The connections between circuits can now be made permanent.

It is assumed in this discussion that the polarity of the potential transformers is known.

C. O. VON DANNENBERG.
New York, N. Y.

Fuse Cause of Trouble With Heat Regulator

IN CONNECTION with automatic temperature regulation, we use a controller the moving head of which is actuated by the expansion and contraction of liquid contained in an armored tube that is exposed to the air of the container whose temperature is to be controlled. When the temperature exceeds a certain predetermined value, the hand touches a contact post on one side of the controller; this establishes a by-path which short circuits the coil of a relay the secondary circuit of which energizes the contactor so that the main heating circuit is opened or closed, as the hand makes contact with the stopping post or with the starting post. Trouble was experienced with the regulator hand overshooting and thereby raising the temperature higher than desired. The short-circuiting circuit established by the stopping post was investigated for loose connections, but none was found. The fuse itself was tested for continuity and found to be in good condition. A new fuse was installed, and then another, both being of the same rating as the suspected fuse; with none of the three similar fuses in circuit, could the controller be depended on to shut off the heat at the maximum desired temperature indicated on the recording thermometer and for which temperature the controller was adjusted. Finally the fuse was removed and the fuse clips connected together with a strand taken from a No. 18 extra flexible conductor. Under these circumstances the control was entirely dependable, showing that the fuses themselves were in some way responsible. Next a fuse of the same rating was removed from the starting circuit, in which it had been installed for many months, and put into the stopping circuit, while one of the suspected fuses was installed in the starting circuit. With this interchange of fuses, the control became entirely dependable. This left only one conclusion to be drawn; namely, that the resistance of the fuse was so high that the by-path circuit of which it was a part, ceased to be a short-circuit around the relay coil which thereby was enabled to retain current enough to keep the relay contacts closed. Since changing fuses no further trouble has been experienced. J. A. HORTON.
Brooklyn, N. Y.

Mechanical Devices in Power Service

(*Continued from page 68*)

Lockwood, Eslick & Pfohl, Buffalo, N. Y., have put on the market an anti-corrosive solution known as Gardco. This material has the appearance of an enamel or paint. It is claimed to prevent corrosion of iron, steel or zinc and to be impervious to the action of acids and alkali.

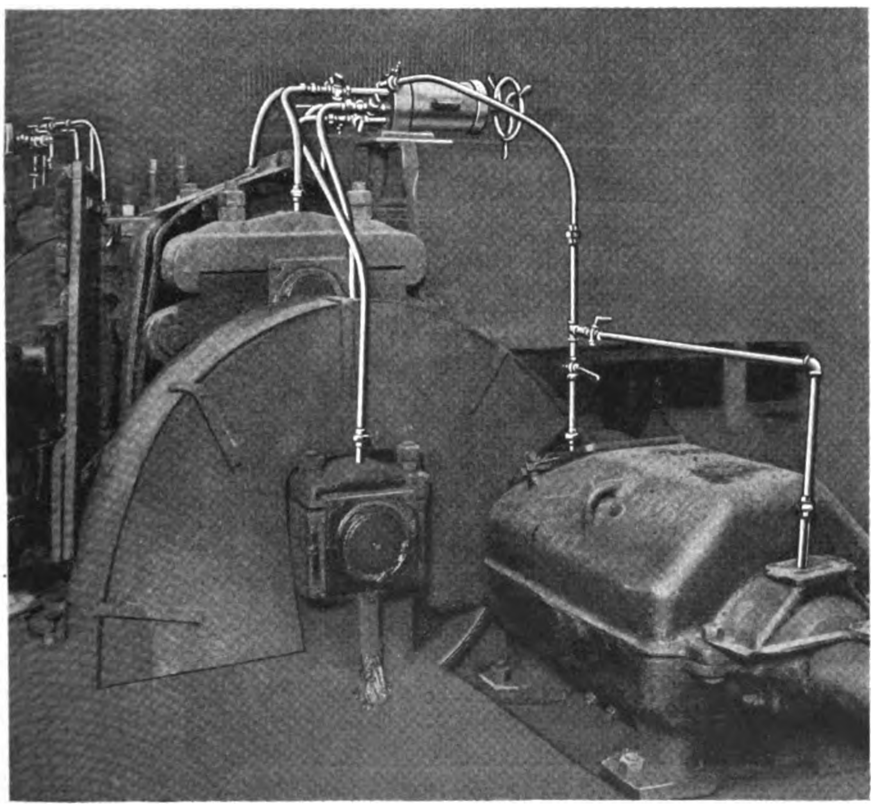
Glow-Brite Co., Cleveland, Ohio, has developed Glow-Brite, a liquid factory glass cleaner. It is claimed that this material will remove dirt and grime from glass almost instantly.

Crown Die and Tool Co., Chicago, Ill., has brought out a portable vise bench. This bench is made largely of malleable iron and is strong and rigid, but light enough to be readily transported.

The Borden Company, Warren, Ohio, has put out two new pipe cutters for handling larger sizes than the cutters heretofore made by this company. These tools can be operated in any position on the pipe by hand or, if desired, they can be arranged for power drive.

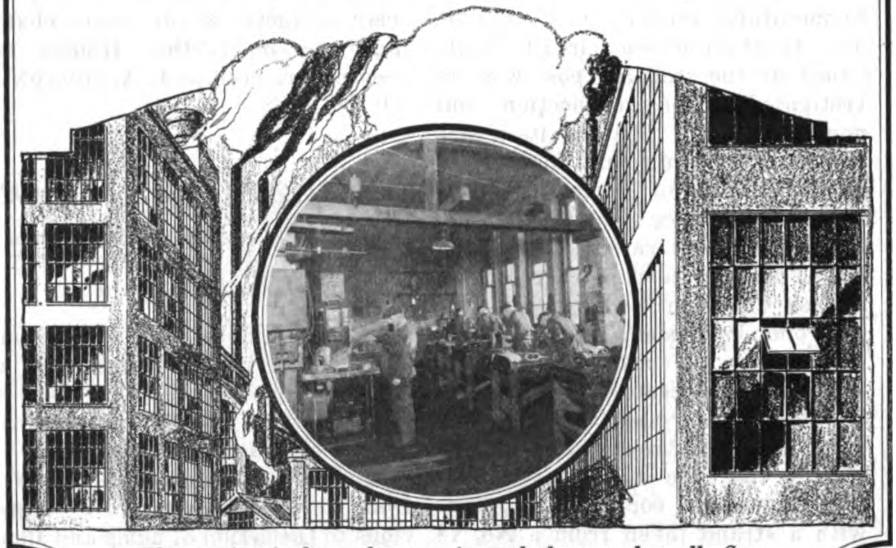
Cling-Surface Co., Buffalo, N. Y., is marketing Cling-Surface belt treatment in medium and light densities and in bar form, as well as in the heavy density obtainable heretofore.

Quickfix, a compound for repairing concrete floors has recently been developed by The Master Builders Company, Cleveland, Ohio. When used according to the method specified by the manufacturers, it is claimed that this material will produce permanent patches that can be used two days after installation, as compared with the two to three weeks' period heretofore needed for concrete patches to harden.



Lubrication of the bearings of this cold scarfing machine is made easier and safer by the use of the Keystone Manifold Safety Lubricator, made by the Keystone Lubricating Co., Philadelphia. Pa.

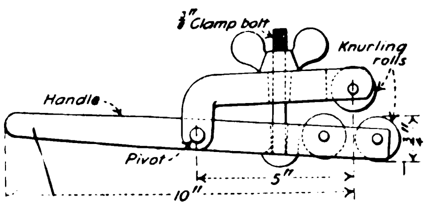
In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Simple Knurling Tool for Hand or Lathe Use

WHERE a small knurling tool is required for general use the simple tool shown in the illustration will be found to be very useful, as it can be used by itself or in connection with the turning lathe, or the speed lathe. Due to the special clamp construction, it is possible to set the knurling rolls against the work, which is held in a vise or chuck, and use the handle to turn the tool about the work, thus embedding the corrugated faces of the knurls into the surface. When this tool is used on the lathe it is not necessary to use the tool post.



With this tool the piece to be knurled is held in a vise and the tool turned around it by hand.

As shown in the illustration, the tool comprises three corrugated rolls about ¾ in. in diameter which are mounted in two hinged, forged-steel holders. One of the holders is about 5 in. long and is pivoted on the other which is about 10 in. long, the extension on this part forming the handle for holding the tool. A single clamp bolt between the two hinged sections provides a means for holding the knurling rolls firmly against the work. This knurling tool will be a desirable addition to the individual tool kit and can be used on many small jobs without the delay occasioned by chucking work in the lathe or securing a tool-post knurl.

Washington, D. C. G. A. LUERS.

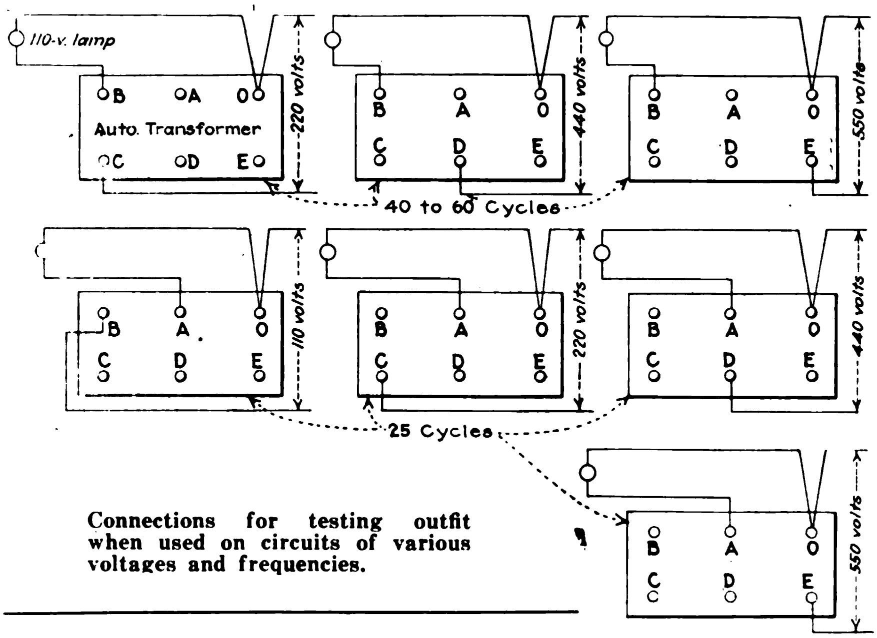
Easily Made and Compact Testing Lamp for Use on 550-Volt A. C. Circuits

IN THE August, 1923, issue of INDUSTRIAL ENGINEER, page 416, I described a handy testing outfit which we use when making tests on 550-volt alternating-current circuits. As was stated before, this outfit consists of one of the small transformers used in connection with the no-voltage release on K-20 Canadian General Electric oil circuit breakers, and an incandescent lamp, mounted in a wooden box.

The diagram of connections for using this outfit on 550 volts was not correct, as given in the article in the August issue. The accompanying illustration shows the proper connection.

Inasmuch as this device may also be used for testing at 440 and 220 volts, at either 25 or 60 cycles, I have also shown the connections which should be used under these conditions. J. H. SAUVE.

Reardon Pulp and Paper Company, Temiskaming, Que., Can.



Connections for testing outfit when used on circuits of various voltages and frequencies.

Copper Balancing Strips Cause of Armature Burnout

CIRCUMSTANCES under which the armature of a motor burned out recently were so unusual that they may be of interest to the readers of INDUSTRIAL ENGINEER.

This armature was of the closed-slot type and had no bands on it. In order to balance it, the winder had put copper strips in about five of the slots and evidently had not taken the trouble to insulate the strips from the core. After the motor had been in operation for some time the armature burned out and had to be completely rewound. On examination it was found that the fiber wedges and the insulation of the wire of the coils lying in the

slots in which the copper strips had been placed, had been thoroughly charred and burned.

The only explanation I could find was that heavy currents were induced in these strips as they passed under the pole pieces. The copper was then heated to a temperature high enough to char the wedges and eventually burn the insulation on the wire. GEORGE RINGNESS.

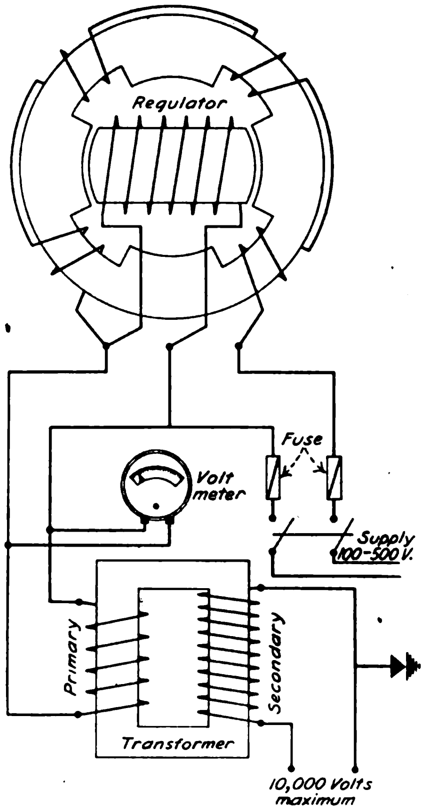
Peoria, Ill.

Methods of Making Dielectric Tests on Insulation of Electrical Equipment

ELECTRICAL equipment in industrial plants often has to undergo repairs, and it is necessary on their completion and before the apparatus is again placed in service, to test for faulty workmanship or material. Insulation repairs should be capable of withstanding a pressure test at least double the rated voltage of the apparatus on which the repairs have been made.

There are two methods of applying a high-voltage test to electrical apparatus. The full pressure may be switched on at once, or provision may be made for gradually raising the pressure from a low value up to the required voltage value for the dielectric test.

Imagine the high-tension winding of a transformer with one end attached to the terminal of a single-pole switch used for interrupting the connection to a source of high voltage. Before the switch is closed, the entire transformer coil is at earth potential. At the instant of contact between the blade and the switch jaws, the wire leading from the switch to the first turn on the transformer coil is raised immediately to the potential of the line. The remaining portion of the coil will become charged in an infinitely short time, but as the charge has to pass through a highly inductive winding it is momentarily held up while the successive layers are being raised to the potential of the line. This results in a momentary high potential between the outside layers and may reach the full voltage at the instant of closing the switch and cause across the outer layers of the coil an almost invisible discharge which punctures the insulation. The discharge contains a very small amount of energy, as only sufficient will pass to bring the remainder of the coil to the potential coil vanishes. This discharge is objectionable, and can be entirely eliminated by applying the pressure gradually to the coil, enabling it to reach a high potential without any



Connection diagram of testing outfit for making high-voltage tests.

of the line, when all difference of potential between the layers of the appreciable difference of potential existing at any time between the layers of the coil.

The diagram shows the connections for a testing apparatus designed to give a secondary pressure from zero to 10,000 volts on a primary supply voltage of 100 to 500 volts, as desired. The apparatus consists of an induction regulator of suitable capacity for the transformer with which it is to operate. The primary side of the regulator is connected to the supply, while its secondary terminals feed the leads of the primary side of the transformer, which may have taps corresponding to the maximum test pressures which the apparatus can supply with the regulating transformer set for full voltage. A voltmeter provided with a double scale is connected across the leads of the primary side of the transformer, one scale reading the low or primary voltage, while the other scale is marked to register the corresponding high-pressure potential delivered for the impressed primary voltage. The iron core upon which is wound the secondary of the regulator, is movable, and may be rotated through 45 deg. In the position of zero potential, the secondary is so placed that the ends of the core are opposite the narrow portions of the surrounding iron ring on which is wound the primary winding in series with the line. In that position no lines of force from the magnetized ring find their way into the movable core, and consequently no voltage is induced in the secondary winding. When the core is slowly rotated by means of a hand-wheel, its ends gradually assume the position shown in the figure, corresponding to maximum voltage, which results from the core being opposite two of the definite pole-pieces on the surrounding core. It will be noticed that this method gradually builds up the testing voltage from a low value to the value required for the dielectric test.

One important point in making pressure tests is that of determining the proper value of the testing voltage to apply. When making tests of alternating-current apparatus, it is important to determine whether the apparatus is intended for service with the neutral grounded or insulated.

If the neutral is grounded a dielectric test to earth equal to twice the phase voltage should be applied. This would be equal to twice the line voltage divided by the square root of 3. If the neutral is ungrounded the dielectric-test voltage should be twice the line voltage. There is no objection to applying dielectric tests to d. c. apparatus with a supply from an a. c. circuit, but precautions are necessary to prevent applying too high a voltage. In dealing with alternating current, all references to measurements of current or voltage mean their r. m. s. values. This value is equal to 0.707 of the actual maximum values reached, so that when an a. c. voltage of 1,000 volts is shown on a voltmeter, the actual stress placed upon the insulation is that produced by $1{,}000 \div 0.707 = 1{,}400$ volts, approximately. Therefore, when a direct-current machine is to be tested, due allowance must be made for the maximum values of e.m.f., when arriving at the testing pressure that is to be used. A. FOKES.

Walton-on-Thames, Surrey, England.

Recent Electrical Equipment

(*Continued from page 80*)

Joseph Weidenhoff, Chicago, Ill., has developed a new armature tester known as the Armature Test-o-meter. He states that the armature to be tested is placed in this device and contact fingers are applied to each successive pair of commutator bars as the armature is rotated in the gap between the pole pieces of the device. Readings are given on a meter which shows whether a coil is defective, the exact nature of the fault, and the slots in which the defective coil is wound.

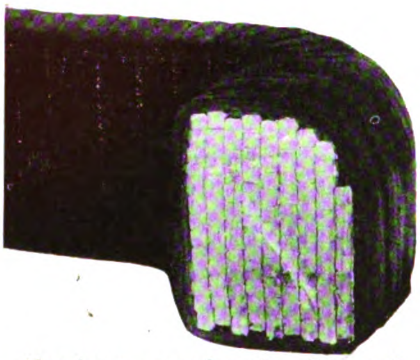
Miscellaneous Tools.—The Martindale Electric Company, Cleveland, Ohio, has developed a new commutator slotter which is designated as the Imperial Undercutter. The maker reports that this undercutter is the only one that will cut a "V" shaped slot, and claims that a "V" shaped slot is best because it is self-cleaning at all times, automatically prevents undercutting too deeply, and practically avoids the possibility of leaving strips of mica along the edges of the bars flush with the commutator surface.

The National Electric Mfg. Company, Pittsburgh, Pa., has developed a new electric hammer drill which is known as the Syntron. Its mechanism consists of a hardened steel piston moving in a cylinder in which two powerful field magnets energized by alternating current are so arranged that when current passes through the windings the piston is given a reciprocatory motion in synchronism with the supply voltage. The manufacturer reports that the cost of operation is surprisingly low and that the Syntron may be plugged into any light socket.

Syntron electric hammer made by the National Electric Mfg. Company of Pittsburgh, Pa.

This hammer makes 3,600 strokes a minute and is adapted for drilling through stone, concrete, masonry and the like.

The Westinghouse Electric & Mfg. Company states that it has made an application of a rectigon controller to a reciprocating solenoid hammer for drilling or cutting stone and concrete, chipping castings or work of a similar character.



Aluminum wound series field coil made by the Economy Electric Devices Company, Chicago, Ill.

The oxidized aluminum on the surface of the wire forms the insulation between turns on this series field coil.

The General Electric Company has developed a new method of testing underground cables to determine the condition of the insulation and to locate cable faults. High-voltage direct current obtained from a kenotron is used. A kenotron is a rectifier that is an off-shoot of the radio audion or vacuum tube.

The Electric Tester Manufacturing & Sales Corporation, of Portland, Ore., has brought out a fuse tester which can be used on any voltage from 100 to 600 without any changes. The maker points out that it is safer than the old lamp and socket method of testing and that it prevents the breaking of so many test lamps, due to dropping or putting a low-voltage lamp on a high-voltage circuit.

The Black & Decker Manufacturing Company, of Baltimore, Md., announce a portable electric screw driver and socket wrench for heavy duty production work. The maker states that this tool, weighing but 15 lbs., has been designed particularly for driving very large wood screws, lag screws, and running up nuts on large bolts. The spindle is equipped with a positive clutch which automatically disengages when the forward pressure on the tool is released.

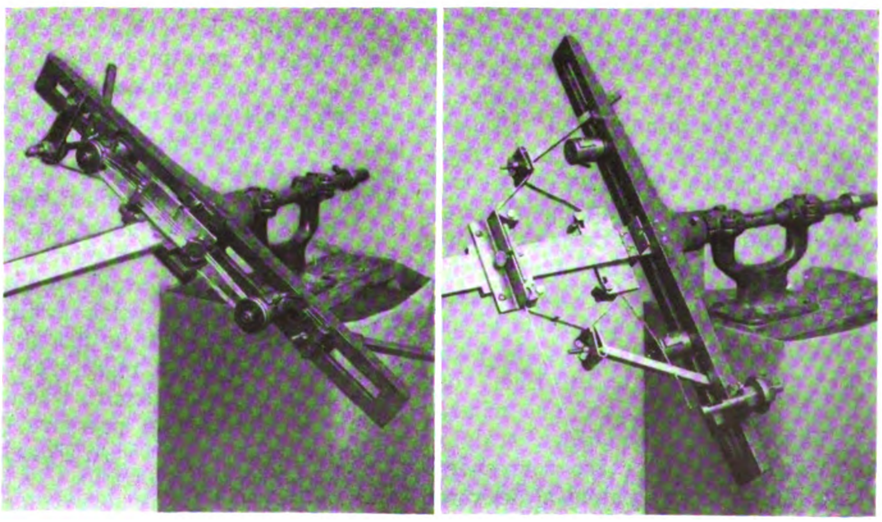
The Easy Manufacturing Company of Lincoln, Neb., has put on the market a new size of pipe pushing machine which it states will force conduit ranging from 3/4 in. to 2 1/2 in. through any ordinary soil. The maker states that with this machine it is unnecessary to dig a trench for laying conduit underground.

The Hobart Bros. Company, of Troy, Ohio, has developed a device for charging storage batteries from a constant potential circuit. The appliance consists of a carbon-pile resistance, an ammeter, a clamp for connecting to the supply bus and a connector, combined in one device.

The Economy Electric Devices Company, Chicago, Ill., is introducing to industrial plants an aluminum-wound series field coil which

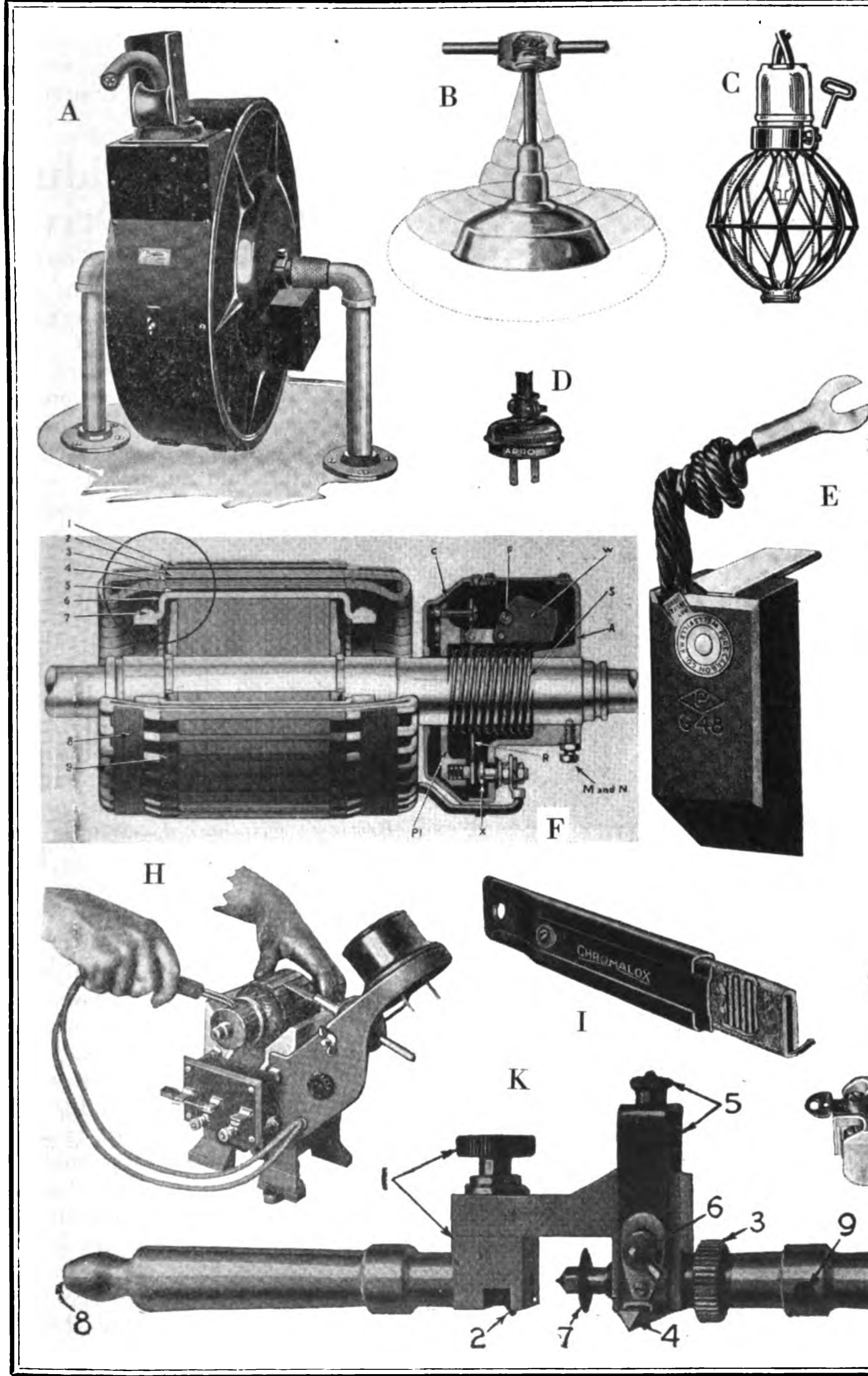
Combination coil winding and spreading machine made by B. T. Coil Former & Tool Company of New York, N. Y.

After the coil is wound as shown in the left-hand picture it is spread either by hand or by turning a crank on the end of the machine.



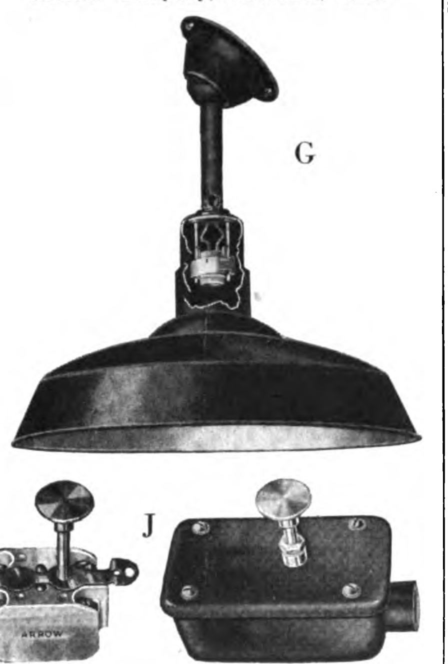
has found a wide application in the street and interurban railway field. Aluminum has the property of oxidizing very easily and when this oxidation is produced by chemical means there is formed around the conductor a dense, hard film which the maker says obviates the necessity of insulation between turns of a series field coil. It is pointed out that these aluminum-wound field coils are designed to give the same field strength as copper coils but have the following advantages over copper coils: longer life, approximately 50 per cent weight reduction, more rapid conduction of heat from coil, less affected by moisture, less chafing, less renewals and less total cost. The Economy Electric Devices Company takes advantage of the high salvage value of a mechanically damaged aluminum field coil and makes a replacement proposition under which it states that it will furnish duplicate coils for 60 per cent of the sale price of a new coil, plus the return of the damaged coil. The maker states that this gives the user of these coils an exceptionally low ultimate cost and no higher first cost.

The Pure Carbon Company, of Wellsville, N. Y., has developed a new brush known as Grade G 48. The maker states that this is a soft graphite grade of laminated texture and is so designed as to bring the laminations across the width of the brush, resulting in a high resistance across the grain, rather than with it. The ratio of the resistance is approximately five and the manufacturer points out that this grade has decided merits from a commutation standpoint in cutting down cross bar currents. The material across the width and along the length has a resistance per



Wiring devices and tools that will save money for the operating or maintenance departments.

(A) is a reel for paying out and automatically retrieving conductors. (B) is a condulet cover which has a universal joint that holds a light fixture in a vertical position even though the condulet is tilted. Both (A) and (B) are made by Appleton Electric Company, Chicago, Ill. (C) is a lamp guard made of expanded steel and designed for the new mill type lamps. Made by Flexible Steel Lacing Company, Chicago, Ill. (D) is a plug with a grip for clamping to cable. Made by Arrow Electric Company, Hartford, Conn. (E) is a laminated brush made by the Pure Carbon Company, Wellsville, N. Y. (F) is the rotor of type TR motor made by Triumph Electric Company, Cincinnati, Ohio. (G) is a swivel hanger made by Quadrangle Manufacturing Company, Chicago, Ill. (H) is an armature testing machine made by Joseph Weidenhoff, Chicago, Ill. (I) is a strip heater made by Edwin L. Wiegand Co., Pittsburgh, Pa. (J) is a push and pull switch and enclosing box made by Arrow Electric Company. (K) is a commutator slotter made by Martindale Electric Company, Cleveland, Ohio.



cubic inch of 0.0015 ohm and the resistance across the thickness is approximately 0.008 ohm. The maker reports that this brush has a very wide range of service in the graphite series and is especially adapted for slotted commutators on large generating equipment and for this class of service the brush has shown very exceptional results on large installations during the year of 1923.

The C. J. Tagliabue Manufacturing Company, Brooklyn, N. Y., has added an electric, contact-type temperature controller to its line of instruments. By means of this instrument the temperature of any device such as a refrigerating unit may be automatically controlled.

The Autovent Fan & Blower Company, Chicago, Ill., has developed a portable window ventilator which the manufacturer reports is especially adaptable to industrial plants. The ventilator is furnished complete with an adjustable frame which is formed from sheet steel and is so designed and constructed that it is adjustable to any width window frame. This unit is also furnished with an 8-ft. extension cord and plug so that the fan can be conveniently attached to a light socket or other outlet. This company has also added to its line an acid-moisture-proof fan, which has an aluminum frame motor, totally enclosed so that there is no possibility of corrosive substances such as acid fumes, gases, or foreign particles entering the motor. The Autovent acid-moisture-proof fan is, therefore, especially adapted for battery charging stations, dye-houses, enameling and plating departments; in fact, every place where an acid solution is required for a manufacturing process.

The Albert & J. M. Anderson Mfg. Company, of Boston, Mass., has brought out a very high capacity plug and receptacle. The new device is rated at 1,500 amp. and 440 volts. Dossert & Company, New York, N. Y., report that installation costs can be reduced by the substitution of Dossert connectors for disconnecting switches on the secondaries of distributing transformers, where a disconnecting switch is installed only to give an easy means of isolating transformer secondary.

New Haven, Conn., has put on the market a new conductor which is designated as "panel wire." The manufacturer reports that the insulation on this wire includes nothing but asbestos, and is indestructible by fire, will not deteriorate in service, nor will the insulation crumble.

The Chicago Solder Company, of Chicago, Ill., reports that its Kester self-fluxing wire solder has recently been approved by the Underwriters' Laboratories, stating that the fluxes used are not likely to cause corrosion to the soldered parts and that the fluxes form a secure mechanical and electrical bond between the solder and metal to which they are applied. The Kester solder incorporates the use of three types of flux which is enclosed in the hollow structure of the solder.

Wiring Devices

The Adapti Company, of Cleveland, Ohio, has recently put on the market an "Always Vertical" condulet cover which is designed to permit a lamp fixture or pendant to hang correctly even though the outlet box has to be installed at an angle, due to the shape of the roof or the manner in which the conduit must be installed. This cover has a universal joint which permits the pendant to adjust itself as much as 20 deg. from the normal to the condulet cover. The Appleton Electric Company, of Chicago, Ill., manufactures a combination hickey and swivel fixture joint which performs a similar function. The Quadrangle Mfg. Company, of Chicago also makes a "swivel hanger" which is designed for similar use.

The Appleton Electric Company reports that maintenance costs can be reduced by the use of its heavy-duty "Reelite," a self-contained device for paying out and automatically retrieving electric conductors for power and light. The maker states that this device is particularly adapted to cranes, magnets, electric motor buckets, and arc-welding sets.

The Flexible Steel Lacing Company, Chicago, Ill., has put on the market a new lamp guard especially designed for the new 25- and 50-watt, mill-type lamps. It is made of expanded steel, reinforced and tinned.

The Arrow Electric Company, of Hartford, Conn., has developed an attachment plug with an "Arro-Grip" device. The maker states that this attachment grips the cord end securely so that when the plug is jerked out by pulling the cord, the plug and cord are protected from breaking. This device is also applied to lamp sockets. This company has developed a push and pull switch with a box which is dust-proof and waterproof and is particularly adapted for use in industrial plants where it will be subjected to a great deal of dust or vapor.

The Mica Insulator Company, of Chicago, Ill., has developed a varnished cambric tape that is bias cut and seamless. The Irvington Varnish & Insulator Company, of Irvington, N. J., also make a seamless bias-cut varnished cambric tape. Rockbestos Products Corporation of

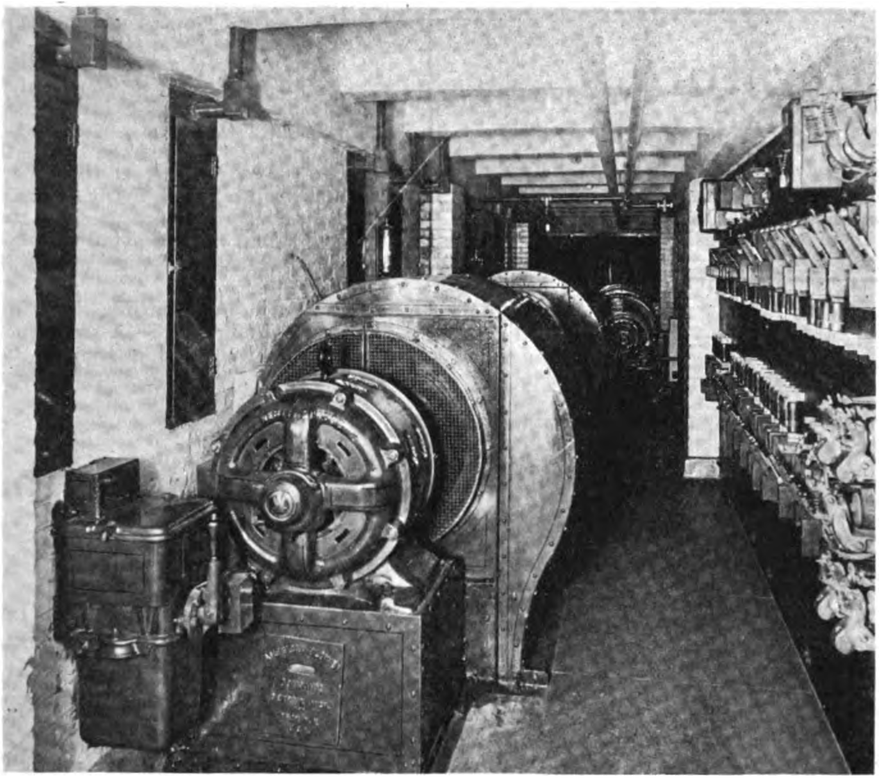
Use of Individual and Group Drives

(Continued from page 60)

individual drives will, therefore, show higher losses than alternating-current or direct-current group drives. Furthermore, where alternating-current power is generated or purchased, the light load losses of converting equipment operated overtime, nights and Sundays to serve a few overtime workers or mechanics doing repair work will more than offset the lineshaft friction losses due to an equivalent amount of overtime work in a group-drive plant. Also, if the proportion of variable-speed motors required is not large, the elimination of such conversion losses will go far toward offsetting the losses from slip-ring alternating current motors on those few drives.

2. *Maintenance of Shafting and Belting Eliminated.*—Where individually-driven machines can be directly coupled to their motors without compensating disadvantages, the elimination of power-transmitting intermediaries is a very real advantage. In this class of drives come most centrifugal pumps, some fans such as cupola blowers and high-speed centrifugal compressors for forge fires, oil furnaces and the like. It is very general practice to direct-connect fans wherever possible but in the light of fifteen years' experience, the writer favors belt drive for reasons which will be given later.

3. *Cleaner Shop.*—In certain industries such as the textile industry, any gain in making the shop cleaner is worth considering and it



Some machines run at so high a speed that operation from a group lineshaft is inconvenient or impossible.

In such a case, if they offer a fairly heavy load approaching their maximum load, they can be individually driven to advantage.

may even be a controlling cause of choice.

4. Better Light with Individual Drive.—Better lighting obtained with individual drive is a point emphasized in most of the published discussions on this subject. It is true that in the old type of manufacturing building with low ceilings and inadequate window area and an engine drive involving much heavy shafting and large belts, this point is well taken. With manufacturing buildings as they are constructed nowadays, "walls all windows" and high ceilings, the shafting necessary for an intelligently planned group drive involving 10 hp. to 50 hp. groups cannot be said to seriously interfere with either the natural lighting or whatever artificial illumination is used.

5. Closer Speed Adjustment of Tool to Work.—Previous to the advent of high-speed steel and scientific management, the great majority of machine tools were limited to three or four speeds, generally obtained by means of cone pulleys. When a closer study of speeds and feeds led to a demand for finer speed adjustment, the first solution generally offered was individual, direct-current electric drive with multiple voltage and field control. This was effective but very expensive, as are all variable-speed motor drives having a considerable speed range and requiring full torque at low speed. The cost and complication of this system led to the development of various other methods of reaching the same result. Some of these schemes involved the use of direct-current motors with gears for the major changes and field control for variation between the speeds given by the gears; single-voltage, direct-current motors with compensating windings, practical for speed ranges as great as six to one; the two-speed and four-speed alternating-current, squirrel-cage motors, the latter with two windings and consequent pole connections for half speed on each; and so on.

At the present time machine tools for group drive are obtainable with as many as eight speeds by quick gear shift, and the possibility of sixteen speeds by the use of an ordinary two-speed countershaft. It is doubtful, whether any ordinary lathe, for example, gains appreciably in output by finer speed adjustment than this affords. There are cases where a wide range of speed control is necessary on a considerable number of machines, including machines with heavy individual power demand. Such a condition generally justifies the direct-current individual drive.

B. Location of Machines to Suit Continuity of Manufacturing Processes without Regard to the Location of Lineshafting.—If the arrangement of lineshafting is intelligently planned, location of group-driven machines in proper sequence and position for economical manufacturing seldom offers any particular difficulty. In those instances where this is not true by all means use individual drive for the machines affected. In my experience the instances of this sort comprise less than 5 per cent of the total number of machines. Most of such cases are machines which are best located in rooms or parts of rooms with no other power-driven machinery nearby.

C. When only a Small Proportion of the Installed Machines are to be Operated, as for Overtime or Slack Season, it is not Necessary to Operate Idle Shafting and Belting.—In the rare cases of a single machine in a room frequently operated overtime or all night it is often best to drive that machine individually. When several related machines carrying on the successive steps of a process are operated during slack seasons, with several other groups shut down, it is frequently possible to group these machines on one motor. Where the reduced operation will continue for a considerable time, as during a dull season, it is possible to remove the belts from the group-driven lineshafts to the countershafts and thus avoid the greater part of the power loss. In general, the power loss is small, and amounts to far less in a dull season than the fixed charges on the extra investment which would have been required to install individual drive.

D. On Large Work the Tool May be Taken to the Work, Instead of the Work to the Tool.—On very heavy work, such as large engine bedplates, slow-speed alternator field frames and the like, it is often more convenient to move the machine tools to the work than it is to move the work. It is self-evident that such portable machines are best suited to individual drive, and this should be employed.

In the foregoing the writer has attempted to show that the reputed advantages of individual drive are not so great as commonly supposed. In another article the advantages of group drives as outlined in the tabulation on page 57 will be taken up and discussed in detail.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

Dossert and Company, 242 West Forty-first Street, New York City.—The sixty-four page twentieth annual catalog of Dossert solderless connectors for stranded and solid wire, rod and tubing, is not only larger but also contains considerable data and information not included in previous catalogs. One of the features is an explanation of the method of putting together a typical Dossert joint. This is well shown by illustrations. In addition, twelve of the most frequently encountered types of joints and how they can be made into Dossert joints are illustrated.

Bond Foundry and Machine Company, Manheim, Lancaster County, Pa.—Catalog K-5 describes and lists the various anti-friction industrial truck casters with ball-bearing swivel and roller bearing wheels. Stationary, rubber-tired and special casters are included.

Bailey Meter Company, East Forty-sixth and Euclid, Cleveland, Ohio—Bulletin 200 describes the "Bailey" tachometer which is used to indicate and record speeds of turbines, stokers, paper machines, fans, centrifugal pumps, and other similar equipment.

Glow-Brite Company, 1006 Rockefeller Building, Cleveland, Ohio.—A new folder, "Let in Daylight, Use Glow-Brite," describes the use of this liquid glass cleaner for cleaning windows and skylights in factories, foundries, steel mills, and the like.

Reliance Electric and Engineering Company, Ivanhoe Road, Cleveland, O.—A 32-page booklet entitled "Electric Motors—How to Choose and Use Them" gives some interesting, practical information on this subject. Among the seventeen topics discussed are: Load factor and motor cost; individual or group drive; getting the right kind of motor; protecting the motor; installing the motor; a method of determining size of motor required; what to tell manufacturer when asking for quotations on motors, and numerous other problems.

The Martindale Electric Company, 11709 Detroit Avenue, Cleveland, Ohio—A folder describes the "Imperial" commutator stone, shows a number of new style handles, additional standard sizes, and lists ten points or advantages, as well as giving a price list. A description of the "Imperial" commutator grinding tool is also included.

Mica Insulator Company, 63 Church Street, New York City—A 4-page illustrated letter in colors describes the application and uses of seamless "Empire" bias-cut tape with savings and points of superiority claimed for it. It also includes data regarding sizes, colors, price and quantity discounts.

E. C. Atkins and Company, Indianapolis, Ind.—The new general catalog number 19 contains 268 pages of illustrations and descriptive matter of the Atkins silver steel saws, saw tools, saw specialties, machine knives, grinding wheels, metal cutting machines, and other tools and equipment manufactured by Atkins.

American Fixture Company, 230-232 West Water Street, Milwaukee, Wis.—Catalog No. 4 describes the various types of "American" Adjustable Electric Light Fixtures, shows how they can be made up of the various parts, and illustrates a number of applications as well as giving prices.

Condit Electrical Manufacturing Company, Boston, 27, Mass.—Industrial Handbook 5002 covers the line of air circuit breakers, oil switches and circuit breakers, oil motor starters, and service switches, and includes handy tables as well as the Underwriters' motor rules.

Union Electric Manufacturing Company, Milwaukee, Wis.—New bulletin sheets are issued to catalog holders which announce and price the new type XA, YA and XB drum controllers and starters.

Sangamo Electric Company, Springfield, Ill.—A folder entitled, "A Study of Meter Lubrication," contains a reprint of an article on that subject by F. C. Holtz, chief engineer of the Sangamo Electric Company.

The Johns-Pratt Company, Hartford, Conn.—A folder describes and gives the list prices of the various sizes of "Vulcabeston" pump valves, which it is claimed can be used under heat, oil, grease, alcohol, chemicals, acids, and other liquids where ordinary rubber valves will not stand up.

Automatic and Electric Services, Ltd., 173-175 Farringdon Road, London, 1.—Leaflets describe the "Wild-Garfield Electric Furnaces" for hardening high-speed steel and also an electric furnace of the radiant heat type for tempering, carburizing, vitreous enameling, japanning and annealing purposes. This furnace is suitable for temperatures up to 1,000 deg. C.

Allan Manufacturing and Welding Company, Inc., Buffalo, N. Y.—A leaflet describes the "Cyl-grind" which is a portable, adjustable grinder for the removal of excessive metal or high spots on cylindrical surfaces. Its special feature is to grind down the inside of cylinders after defective spots have been welded by electric arc or other process. The "Cyl-grind" may be adjusted or set for the desired radius while the wheel is in motion so as to remove the exact amount of excess metal. This grinder is made in two sizes; one adaptable to automotive cylinders and the other for air, steam and water cylinders of larger diameter.

Shepard Electric Crane and Hoist Company, Montour Falls, N. Y.—"A Book of Illustrated Economies" contains 68 pages filled with illustrations of applications of the Shepard Electric "LiftAbout." This is a ½- and 1-ton electric hoist. One of the interesting features of this book is that the installations are from many industries and are accompanied by a short testimonial from the user telling of the advantages and economies of the "LiftAbout."

Buffalo Fuse Corporation, 752 Main Street, Buffalo, N. Y.—A small folder lists the sizes and prices of both cartridge and plug types of "Pierce" renewable fuses.

Four Plants of the Pacific Mills

(Continued from page 55)

of textiles is The Pacific Mills, Lawrence, Mass., which produces printed, dyed and bleached cotton goods, cotton warp, and all-wool dress goods. This Company was incorporated in 1850 and for fifty-nine years its mills were located wholly at Lawrence, Mass. Additional mills are now operated at Dover, N. H., and Columbia, S. C. The area of all factories aggregates 182 acres of floor space.

With 11,000 employes on the payroll, which exceeds $10,000,000 annually, the Company operates 663,232 cotton and worsted spindles and 15,951 looms besides performing the many other operations required in the manufacture of cloth. If the Company's looms were placed end to end they would form a continuous line over 24 miles long. In these great mills the normal product of over 195,000 acres of cotton (about 70,000 bales) and the wool produced by 2,366,000 sheep are woven into cloth each year. About a mile and a quarter of cloth is produced a minute during the running hours. In 1921 the total output reached a value of over $72,000,000.

A better idea of the extent of the industrial magnitude of this industry may be obtained from the following figures on power service equipment in the various mills of this one Company: Over *118 miles of belting* are driven from *21½ miles of shafting.* In addition, *72¼ miles of power feeders and cables* supply power to the *2,482 motors* having a *total rating of 34,585 hp.* The motors range in size from 1/15 to 200 hp. These figures give some conception of the amount of power transmission equipment which must be maintained in proper operating condition for continuous production.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 82 — Chicago, March, 1924 — *Number 3*

The Cause—Not the Crime—Is the More Serious

When Trying to Stop the Practice That These Illustrations Represent

THERE'S a little book called "Protection Up to Date," published by a well-known circuit breaker manufacturer, that I like to read because it contains a lot of uncommon common sense about circuit breakers. It has no use for fuses, but inasmuch as we are not discussing here circuit breakers *versus* fuses, that doesn't matter and I can borrow this statement from that book to bring out the point I want to call attention to in connection with the accompanying pictures:

"Now common sense is not nearly so often found in people as it is in a highly-organized piece of machinery. The first apparatus we built was as *stupid* as a fuse, then gradually we trained it," etc. The operator who is determined to get a job done and does not think much about the nerves of the machine he is using, often believes the fuse is *a stupid thing* that works all right on less than its rated current but goes out on every provocation above that rating and causes him trouble at just the wrong time—that is, when he is working the circuit to its limit. The result is that in desperation and disgust he does one or more of the things that are shown in the above pictures, and commits a crime on fuses that the insurance companies will not forgive and which some states, through industrial commissions, have made a criminal offense punishable by fine and imprisonment.

The practice is bad—very bad in fact—but as fuses have been used in electrical work since the memory of electrical men runneth not to the contrary, and this practice still continues, the cause and not the crime is the problem to deal with. Fuses have their place in electrical circuits and their abuse will never be eliminated entirely until those who are likely to abuse them have a better idea of the reasons for protection in an electrical circuit against fires, possible damage to machines through overloads, single phasing of three-phase motors and the like. Instead of putting a man in jail for overrating a fuse by soldering fuse wire to it or using a fuse element larger than intended, he should be taken aside and given a heart-to-heart talk on fuse construction and how easy it really is to overcome fuse trouble by using the correct fuse; also, how expensive it is not to do so.

Failure to provide the right kind of protection in a circuit and make it unnecessary to go wrong is about as bad as the crime of tampering with the rating of fuse elements. Manufacturers of renewable fuses are working on this problem and in the arguments they have used to sell this type of fuse they have without doubt brought about a much better understanding of the correct use of fuses, but the job is not yet finished. The subject of circuit protection is a big one and we are going to have a lot to say about it in future issues. If you have any ideas that you think are good, let's have them and by getting together and all going in the same general direction we will eventually get somewhere.

Practical Pete

A Glimpse Into the

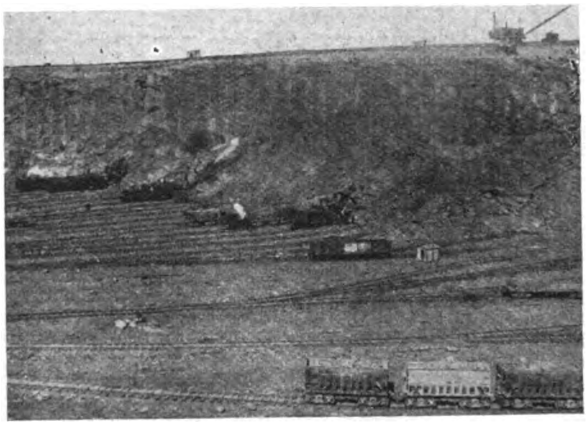
Portland Cement Industry

Where, because of the vast quantities of hard materials to be ground, the wear and tear on the machinery is so great as to require the employment of one man on repair work out of every five men in a cement plant.

IN THE manufacture of Portland cement about 2½ tons of material must be pulverized for each ton of finished cement. If powdered coal is used to burn the cement, about one-third ton of coal must be pulverized in addition for each ton of finished product. To avoid excessive wear on the bearings of the machinery involved, over a million dollars worth of grease and oil are used each year in this industry alone. Even with this care one man in every five employed at the cement plant devotes his time to repair work.

Portland cement was first made in England a century ago. It was so named because when hardened it resembled "Portland" building stone. Portland cement is made from lime, silica and alumina which ingredients may be secured from several different combinations. Some cement mills use cement rock and limestone; some use limestone and clay or shale; others use marl and clay; still others use blast-furnace slag and limestone. In each case the raw materials must be analyzed, blended and treated so as to make a standard, uniform product. Some of the cement plants are located near the quarries, although in other cases the raw materials are hauled considerable distances.

Cement passes through more than eighty distinct manufacturing operations from raw material to finished product. These include quarrying, at least eight crushing and grinding operations, a slow burning at a temperature of 2,500 to 3,000 deg. in a long rotary kiln as much as 240 ft. long, weighing over 600,000 lbs. and large enough to drive an automobile through, pulverizing the clinker in rotary ball-mills until it is finer than flour, sacking with

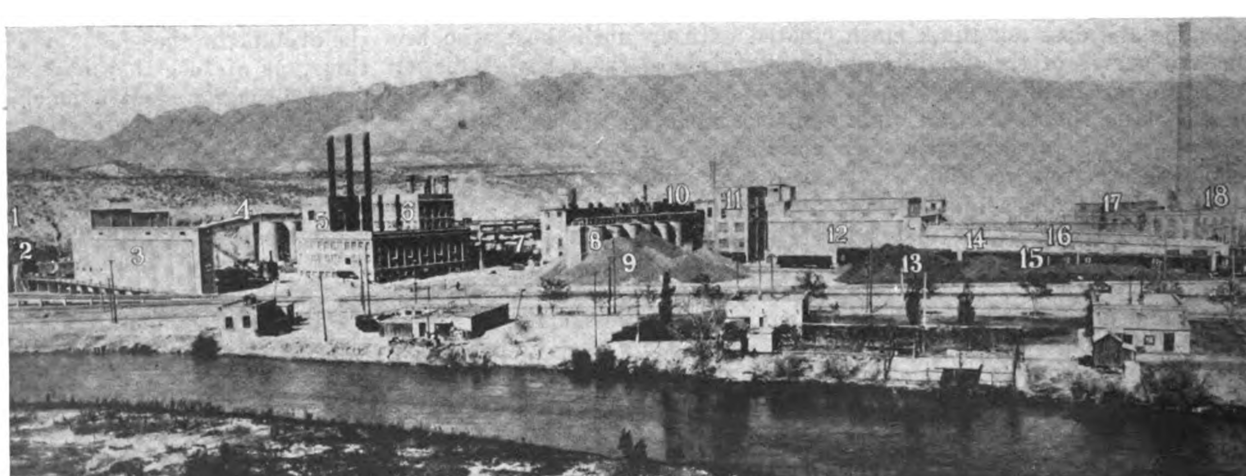


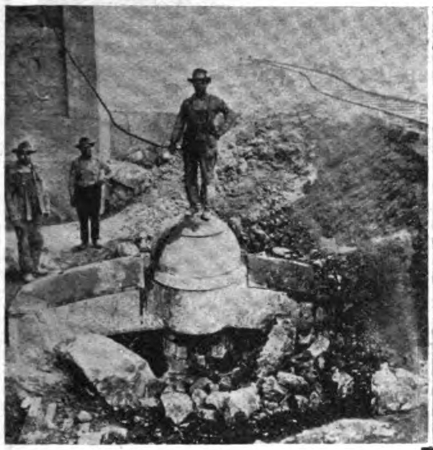
One of the quarries for a cement mill.

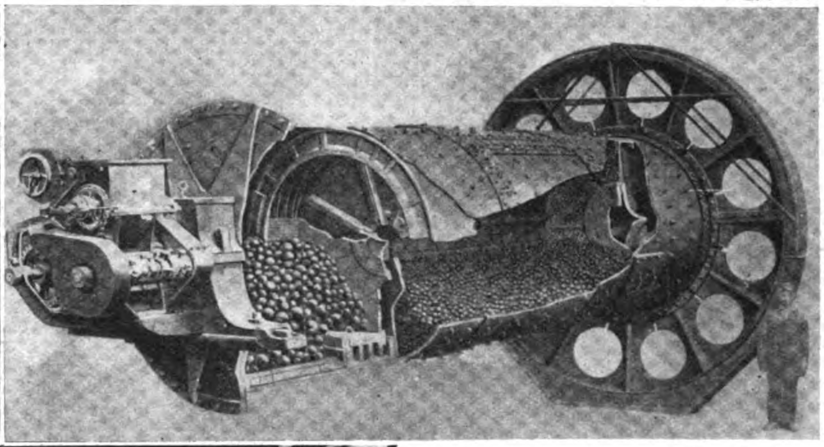
For every 94-lb. sack of cement it is necessary to quarry, mine or dredge over 200 lb. of raw material, including coal. Over 100,000 tons of rock are required daily to supply the Portland cement mills in the United States. In quarrying often 10,000 lb. or more of high explosives are fired in a single shot and loosen 50,000 tons of rock. This is loaded on cars by steam shovels and hauled to the mills. Over 15,000,000 lb. of dynamite and powder are required annually to produce raw material for the cement mills which often are located near the quarries to take advantage of a short haul of raw materials.

Even a moderate sized cement plant, such as this, represents huge scale manufacturing operations.

This is only one of the 120 Portland cement plants in the United States; the largest have a capacity of 100,000 sacks of cement a day. The sequence of some of the different departments which perform the eighty manufacturing operations is shown in the accompanying illustrations. These are: (1) Quarry; (2) rock crushers; (3) raw material storage tanks; (4) belt conveyor taking raw material to grinding mills; (5) raw grinding department where raw material is finely ground; (6) power house and boilers operated by use of waste-heat from the kilns; (7) rotary kilns in which clinker is burned at a temperature of 2,500 deg. to 3,000 deg. F.; (8) clinker conveyor; (9) clinker storage tanks and outside pile; (10) coal grinding mills; (11) clinker grinding department where clinker is pulverized to make cement; (12) cement stock-house; (13) auxiliary coal storage; (14) bag cleaning and storage; (15) cars waiting to be loaded; (16) packing and shipping departments; (17) reserve boiler house; (18) reserve power house. It will be noticed here that raw materials enter at one end of the plant and the finished cement is shipped out at the other.

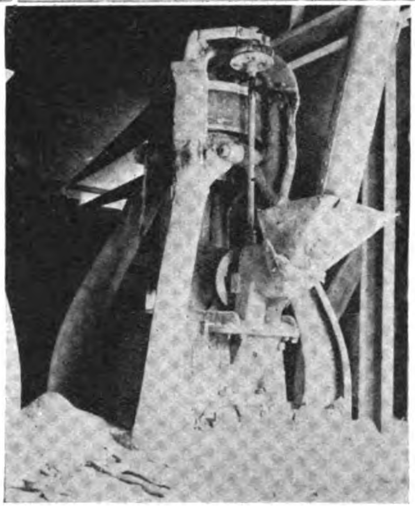






Three types of grinding mills used in cement plants.

Almost $2\frac{1}{2}$ tons of material not including the powdered coal are pulverized in the manufacture of a ton of cement. A large gyratory crusher (above) may weigh about 600,000 lb. and will crush 1,000 tons of rock an hour. This will take rocks weighing about 1,000 lb. and crush them down to small size. Eight crushing and grinding operations are required to pulverize the rock so that 85 per cent will go through a sieve with 200 cross-wires to the inch. This is burned in a kiln (below) and the resultant clinker which is glass hard, is again pulverized in the centrifugal mill (right) or the ball mill (upper right). These ball mills are about the size of a locomotive boiler and hold tons of steel balls which roll and grind the clinker into billions of particles to the cubic inch.



automatic machines, and shipping out. When pulverized, both before and after burning, 78 per cent of the material must shake through a sieve with 40,000 openings to the square inch—fine enough to hold water.

There are now more than 120 cement plants in the country, owned by some ninety companies. In two instances, the producing capacity of the plants runs over 25,000 barrels or 100,000 sacks, a day. At 800 sacks to the car, a day's shipment from one of these large plants may run to 300 carloads or more.

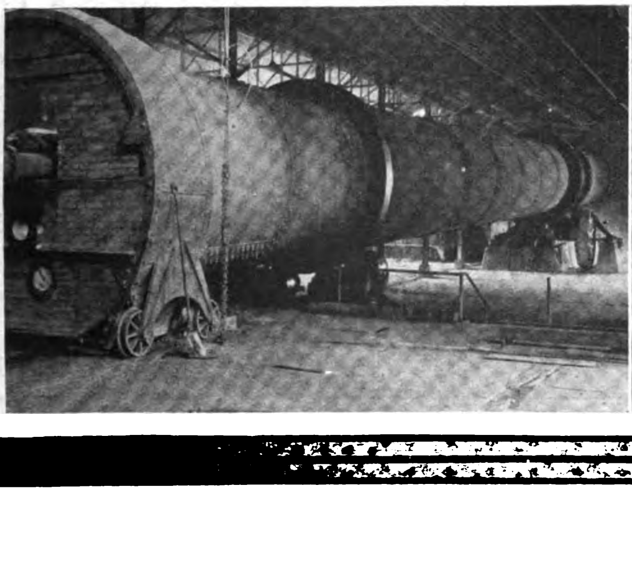
Within short distances of these large plants are others having not more than a tenth of their production. In more sparsely settled regions, other plants operate with a maximum capacity of four thousand sacks a day or less. Since cement is a heavy, low-priced commodity, freight rates play an important part in the delivered cost and the profitable shipping radius is relatively small. The demand for cement is seasonal, with the largest shipments in August.

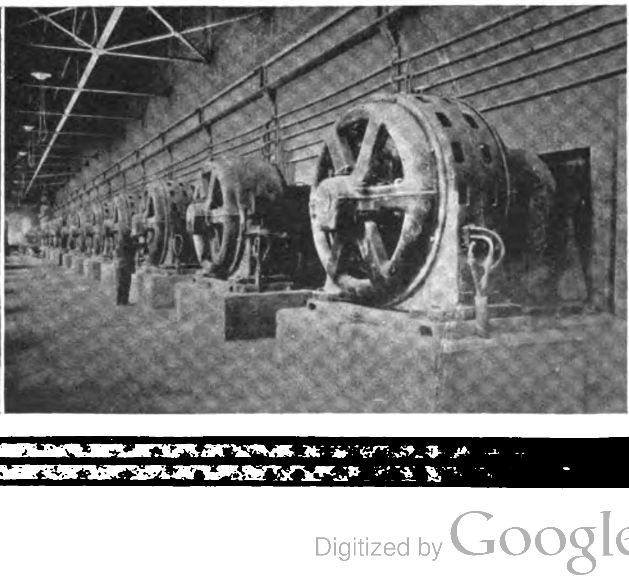
Some idea of the inter-relations of the cement industry to other industries is pointed out in the following facts:

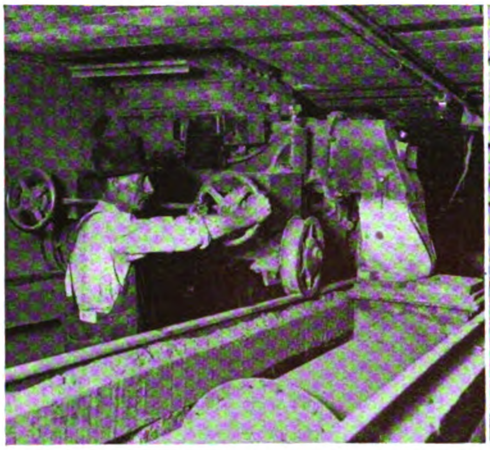
Each ton of cement requires more than one-half ton of coal to supply the heat and power necessary to produce it. According to the manufacturing census this industry is the fourth largest manufacturing user of coal in this country and the third largest user of power per dollar of prod-

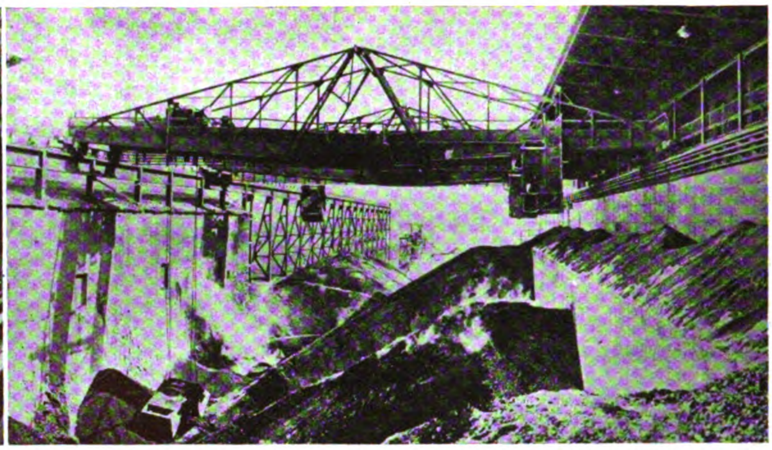
Where the half ton of coal goes which is required to make a ton of cement.

Properly blended and pulverized raw materials are burned to a glass-hard clinker in the large rotary kilns (left) some of which are 240 ft. long and the material requires three hours to pass through. About a third of a ton of powdered coal per ton of cement (or oil or gas) is used for fuel and makes a temperature of 2,500 deg. to 3,000 deg. In some plants the waste heat from the kilns is used under boilers to furnish steam for power. The row of large motors operate mills on the other side of the partition for grinding. Over a million dollars' worth of oils and greases are required for lubrication of the machines and conveyors operating in the dust-laden atmosphere.









Automatic scales (left) weighing and proportioning raw material, and the clinker storage (right).

During the pulverizing process the crushed raw materials are combined in proper proportions as determined by chemical analyses. The final pulverizing mixes these materials thoroughly before burning. After burning the clinker is stored in pits until pulverized. It is handled by traveling cranes and grab buckets. Material handling is a big problem in cement mills because of the numerous times the large quantities are handled in the eighty operations.

uct. Even a medium-sized plant will use as much coal as a city of 20,000 inhabitants.

Over 4,500,000 lb. of grease and 4,500,000 gal. of lubricating oil, costing over $1,000,000, are required in a year to keep the bearings, gears, and hundreds of miles of conveyors, which are used in the industry lubricated. Over 375 miles of belt conveyors and belting alone were worn out last year in the cement mills in this country.

Annually about 60,000,000 cement sacks, or one in every eight shipped out, are lost or destroyed.

Over 60,000 bales of cotton are required to weave the cloth for sacks to replace this loss. The others are returned, inspected, repaired, the top tied, and then stored ready for filling. The sacks are tied while empty and filled through a valve or flap in the bottom by automatic filling machines. Over 55,000 miles of wire are required in a year to tie the sacks.

Due to the wide use of labor-saving devices and the increase in size of cement machinery used, each man employed produces $2\frac{1}{2}$ barrels of cement, whereas 20 years ago he produced only one. Also, today a third less coal is required in the production of cement, than was formerly the case.

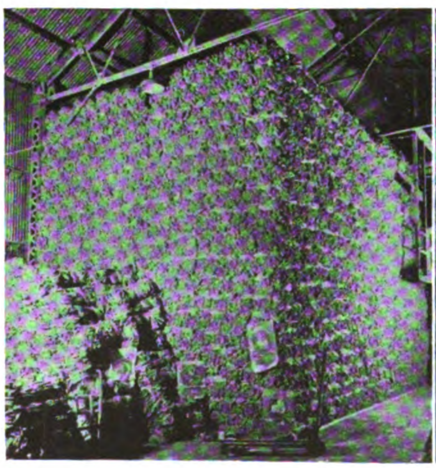
Although this industry, with its large quantities of explosive, high-temperature, crushing and pulverizing machines, and miles of conveyor belts, has many opportunities for serious accidents, safety work is so well organized through the industry that the accident rate is low. For example, one plant employing 350 men had only five minor accidents, causing only twenty days time lost in a year.

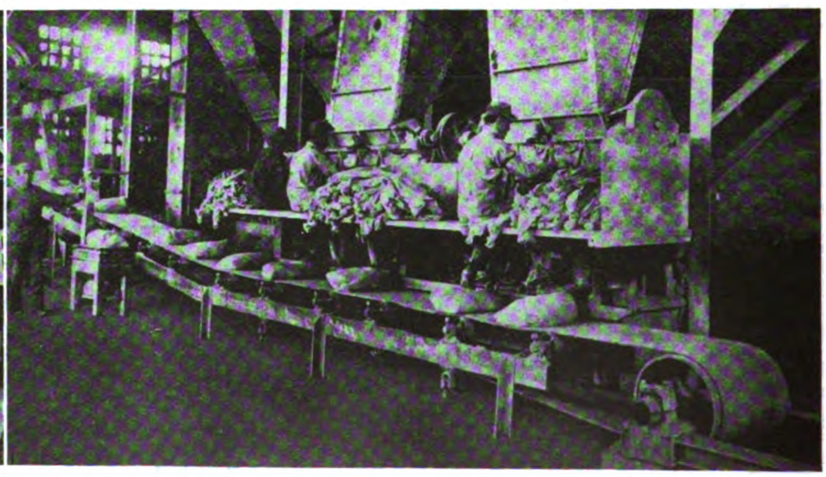
Last year 137,377,000 barrels (four sacks, 94 lb. each to the barrel) of cement were produced last year in the United States, which was a big increase over the previous year. Roads and buildings used a large part of this but there are many other applications.

EDITOR'S NOTE: Acknowlegement is made for assistance of the Portland Cement Association, Chicago, Ill., in compiling this material and supplying photographs.

This pile of sacks are ready for the automatic bag-filling machines at the right.

After sacks are returned from the user they are inspected, repaired, tied with wire and stored ready for filling which is done through a flap or valve in the bottom. The automatic bag fillers weigh the material as it passes into the bag and shuts off at the exact weight. The operator then drops the bag on a belt conveyor which carries it away. A crew of four men can fill 8,000 sacks of cement a day. Formerly this work was done by men with shovels and a gang of four men could by hard work fill about 1,600 bags a day.





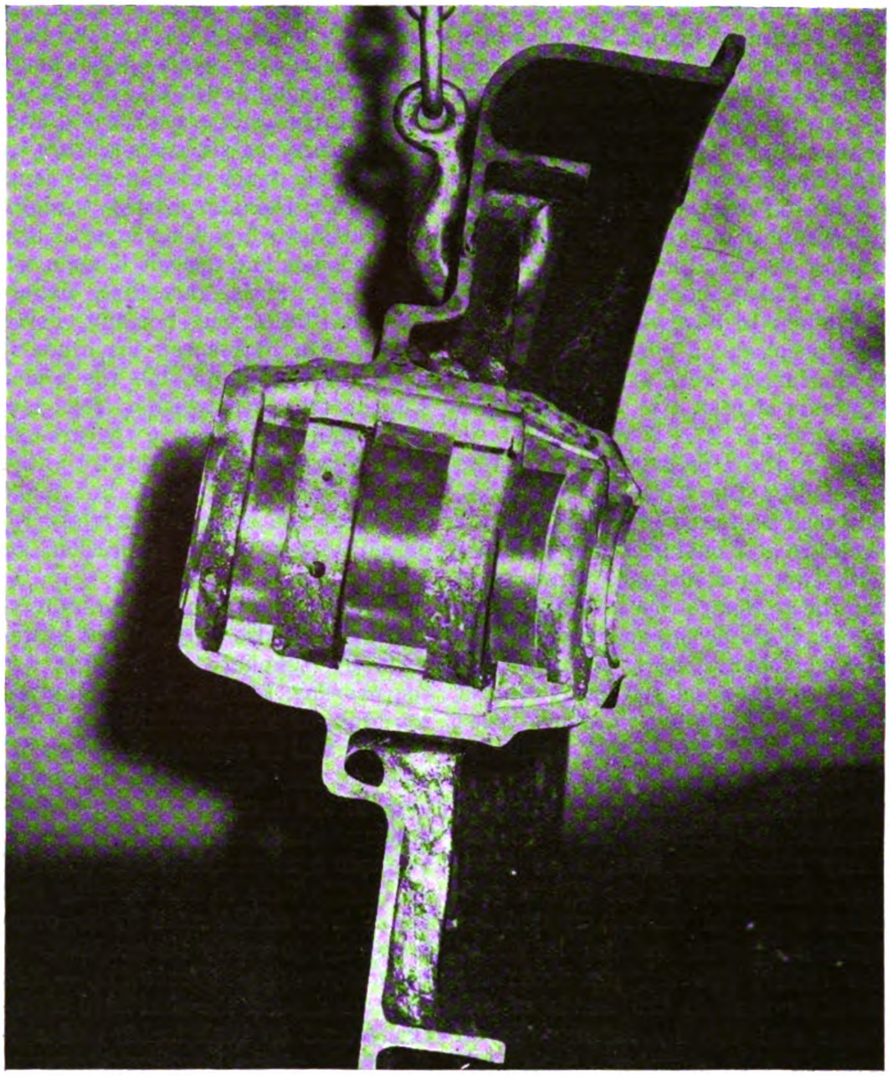
SLEEVE BEARINGS have been condemned, sometimes justly and sometimes unjustly, from design and operating standpoints. That they have been abused and that part of the criticism directed toward them is due to this abuse, few will deny. How far the effects of this abuse can be eliminated in sleeve bearings by the operator and the maker, is of most interest to the user and in this article sleeve bearings are discussed from these standpoints.

Ways to Cure

Sleeve Bearing Troubles

With Construction Details of Motor Bearings and the Good Points of Sleeve Bearings That Are Sometimes Overlooked

By R. PRUGER
Mechanical Engineer, Motor Engineering Dept., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.



This illustration shows one-half of a standard split bracket with grooves in the bearing housing walls to prevent leakage of oil at the split.

THE sleeve-type bearing with oil ring lubrication is widely used on industrial motors in all classes of service. Perhaps due to its ability to stand abuse, as much as to any other cause, it has in many instances been abused by the designer, the manufacturer and the user. The result of this abuse has been a certain amount of trouble with sleeve bearings. In some quarters this trouble has been accepted as inherent in the sleeve bearing, whereas it is in reality something that can be corrected. In this article some of these faults and the corrective measures are discussed.

Remedies Which Are Applied for Oil Leakage

Trouble Due to Oiling.—An investigation of a number of cases has revealed the fact that quite frequently oil troubles may be traced back to the oiler. Some attendants seem to be of the opinion that motors require oiling several times a week or oftener. This may be true if oil escapes in large quantities. In such a case, the matter should be investigated so as to cure the defect rather than continue the evil and favor it by feeding in more lubricant. Motor housings are usually provided with an oil overflow, that indicates the correct level. Under no consideration should this level be exceeded, as it will only cause the oil to overflow, probably into the motor, by way of the clearance between the shaft and the housing bore. Oiling the motor while it is in operation is not good practice and may produce overflowing, since a certain amount of oil is held in suspension by the ring and the bearing. When the motor comes to rest, this oil will drain back into the oil well, and if in excess of the right amount, may overflow.

> THIS IS THE FIRST of a series of articles on bearings of the sleeve, roller and ball designs, that will give the advantages of each compared with the others from the standpoint of meeting the wide range of service conditions in industrial work. INDUSTRIAL ENGINEER invites users and manufacturers to contribute their comments on the information presented in this series from the practical standpoint of improvements in bearing operation that actual service has shown.—EDITORS.

Bearing housings are also equipped with a slot on top, to permit assembling of the oil ring. Oftentimes this slot is rather narrow and if an oil can is used with a large spout which does not enter into this slot, it usually happens that the oil is splashed over the housing and runs down on all sides, dripping off

at the bottom. In this way oil-covered surfaces are produced which are directly in contact with the air currents which are drawn into the motor by the blower. These currents usually travel at considerable velocity, picking up small particles of oil and oil vapor which is again deposited upon the windings, producing in time an oil-soaked condition. Care should, therefore, be taken not to have housings too full nor to splash oil over them, but fill to the correct level, and slowly, while motor is at rest.

Balancing Air Pressure.—If in spite of these precautions oil enters the motor the cause is elsewhere, and may be found in unbalanced air pressure. Housings are provided with two, or sometimes three, seats for the bearing proper. These bearing seats divide the housing into several chambers which, in turn, have holes cored at the bottom to connect them. If these holes are not cored out correctly, which may occur due to shifting of the core in some way when the casting is made, these communicating openings may be entirely submerged by the oil level. Now, the action of the blower produces a partial vacuum around the bearing housing on the inside of the motor, drawing air from the chamber next to the inside of the motor and thereby raising the oil level in this chamber. This may cause overflowing. In such a case it will be found advisable to chip a few small grooves in the bearing seat, well above the oil level, so as to establish a balanced air pressure and free travel between the chambers in the housing. This point is quite essential and must not be overlooked.

On Westinghouse motors this balancing of air pressure is taken care of by coring in a communicating channel at the top of the housing, where this is of the solid type. Split housings have grooves cored in at the sides, which not only establish communication, but at the same time prevent oil from creeping across the surface of the split.

Closing Oil Ring Slot Tightly.—While this communicating channel accomplishes the balancing of air pressures, it must be remembered that cored holes cannot be made unless they have a fairly large cross section, for practical reasons. If we have, therefore, to deal with a high-speed motor, a considerable amount of air is drawn through the housing, entering by way of the oil-ring slot, passing through the cored hole, and reaching the motor through the bore clearance at the inside of the housing. Inasmuch as the oil ring causes considerable agitation of the oil and, furthermore, as the temperature of the bearing tends to vaporize some of the oil, the air passing through the housing will pick up some of this fog or vapor and deposit it upon the windings. It is, therefore, important to keep the housing cover closed. On high-speed machines it is customary to provide the under side of the cover with a felt pad, and sometimes to go to the precaution to screw the cover down tightly. Do not miss this point, but make sure that the cover is correctly replaced after each inspection or oiling.

Incorrect Over-flow Fitting.—Overflowing may also be produced by incorrectly tapping the housing for the overflow fitting. If it is tapped too high, or at an upward slant, the oil level will be registered above normal and may thus reach the inside bore in the housing and cause overflowing. A check should, therefore, be made against the lowest point of the inside bore in the housing and the oil level as indicated by the overflow plug, to verify its position.

Dust-proofing Precaution. — Felt washers around the shaft are oftentimes used on both inside and outside faces of the housing. However, this is a dustproofing precaution and while it will help in a measure to overcome oil leakage, it cannot be looked upon as a permanent cure. Felt will in time become oil soaked and finally permit oil to pass. It will render service as a dustproofing device, and, if it is designed correctly, will also prevent overflowing when the housing is filled too full, but it should not be depended on for more than that. If used as a lining or padding under covers which are screwed down it will be found useful, since it is kept under pressure and an air-tight packing may be produced. However, if felt is used around the shaft, its function is only as stated above.

Quality of Lubricant Used.—The quality of the lubricant is likewise a feature which deserves consideration. Some oils will produce more or less foaming at high speeds. This foam may reach the housing bore, and thus enter the motor. A change of lubricant is the surest and best remedy in such cases. If that cannot be done, a baffle plate may be introduced inside of the housing to form a separating chamber, giving the foam opportunity to settle and quiet down, returning by a communicating opening at the bottom to the oil well. Foaming has been found to occur also on ball-bearing motors and after such a baffle plate was installed the trouble was overcome.

Oil Grooves.—Another safeguard is to get rid of the oil before it emerges at the end of the journal after having done its work. This is accomplished by machining an annular groove near the end of the bearing. This groove need not be more than 1/4 in. to 3/8 in. wide, and from 3/32 in. to 1/8 in. deep, depending upon the size of the bearing and the quantity of oil in circulation. At the bottom of this groove one or more holes are drilled and free communication is established to permit the oil to run back into the oil well before it reaches the end of the bearing. This will considerably reduce the possibility of leakage and relieve the oil thrower on the shaft of much of its work. This is quite important, as the oil thrown off by the thrower against the inner housing wall will run down along the walls and may drip back upon the shaft beyond the oil thrower, whence it may reach the motor. In troublesome cases on very high-speed machines, it has been found expedient to introduce a brass sleeve pressed into the housing bore, and with the inside end slightly curled up, so as to form a small groove which needs to extend only around the upper half. This groove will carry oil flowing down the inside of the housing walls and once past the horizontal center line, it cannot get on the shaft but will drain down directly into the oil well below.

There are, of course, a number of other devices which may be used, such as air shields which establish communication with the outside air, drawing air currents past the housing face and thus preventing air from being drawn through the housing. However, if the housing is well sealed, the seal will be found quite sufficient to overcome oil leakage at all ordinary speeds, and even at high speeds.

Good oil will last almost indefinitely if kept clean and within normal operating temperatures, except for the small amount of loss due to some slight escape of vapor, which is unavoidable.

If air currents are excluded, no dirt or dust is carried into the bearing. There is no reason, then, why a sleeve-bearing motor should not operate with entire freedom from oil leakage and, therefore, freedom from winding failures due to oil. With the bearing in perfect condition, the necessary amount of attention required will also be greatly reduced and the time between oiling periods increased.

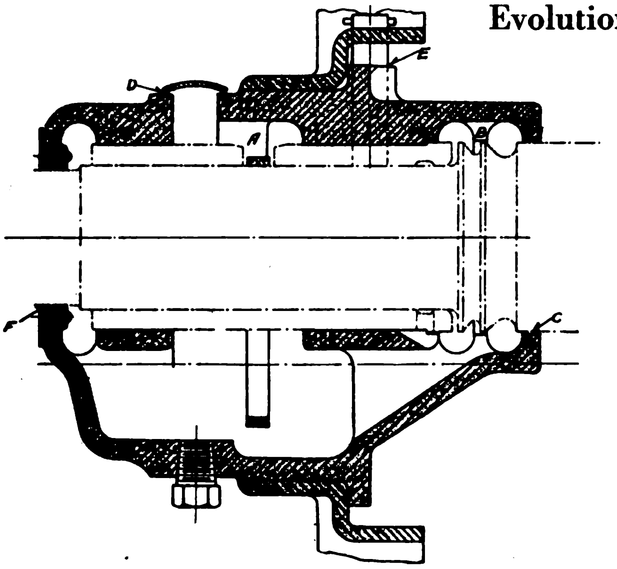
Advantages in the Use of Sleeve Bearings

Frequently long acquaintance and familiarity lets us forget merits and advantages, and dims our sense of appreciation and good judgment in our actions and dealings with the objects which, when correctly applied, have rendered useful service for many years. I believe that claims made in favor of one or the other type of a certain object should be thoroughly substantiated by actual facts and long trials under varying conditions, before setting aside a proven object in favor of a newcomer.

Considering some of the points that we find in the sleeve bearing, we may be able to draw comparisons and balance up against the ball bearing, which is sometimes given preference on one or two counts, such as oil trouble and attention required.

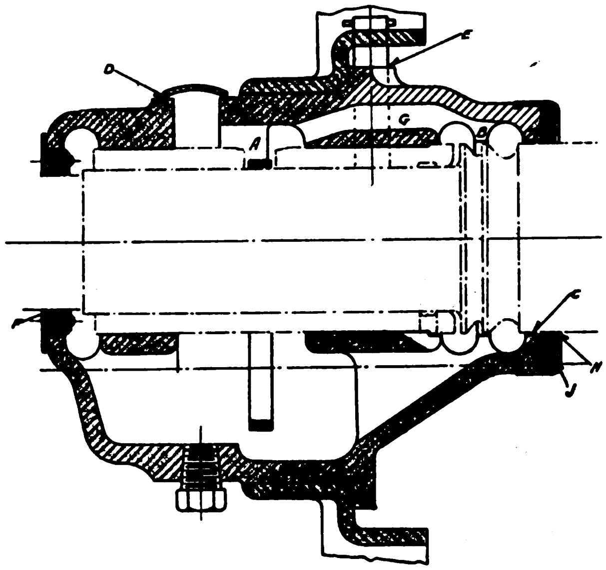
Evolution of the Leakproof Bearing Housing

Improvements are shown in unshaded sections at G, D and J in these drawings.

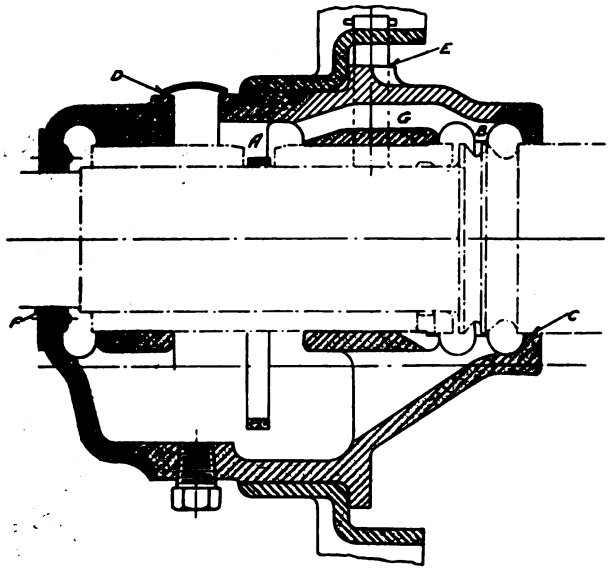


This design has become obsolete due to the five principal difficulties enumerated as 1 to 5.

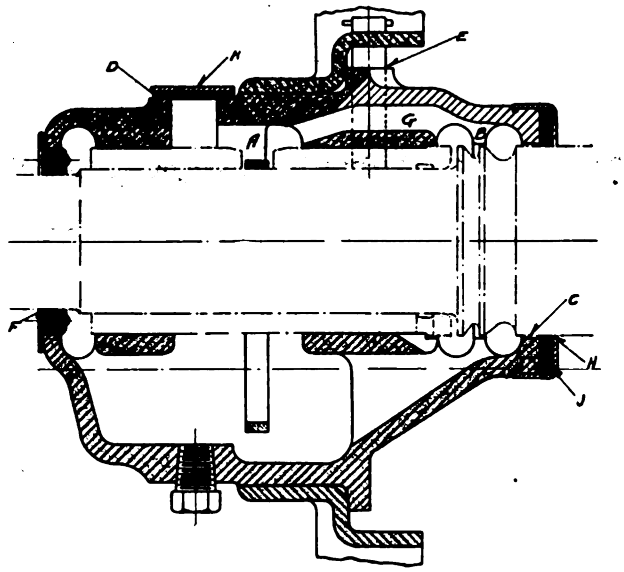
(1) No by-pass for air. Low pressure in chamber *B*, due to blower action, causes oil to escape at *C* if the oil level is temporarily raised too high. (2) Oil poured into the housing faster than it can escape from overflow plug will overflow at *C*, in spite of absence of blower suction. (3) Oil slops out of oil ring slot at *D*, especially at high speeds. (4) Current of air entering at *D* and escaping at *C* carries oil vapor into the motor. (5) Oil leaks out past steady pin at *E*. (6) Portion of shaft at *F* alternately covered by oil-soaked felt and exposed to air (due to end play), throws off a fine oil spray which is carried by the draft of ventilating air into the motor.



Old design improved by addition of an inner-bearing cap (J) to guard against oil leakage from careless filling of the oil reservoir, indicated as item (2) in the caption at the left.



Old design with first improvement: namely, the addition of a by-pass for air at G, to overcome the first cause of oil leakage indicated as (1) in above caption.



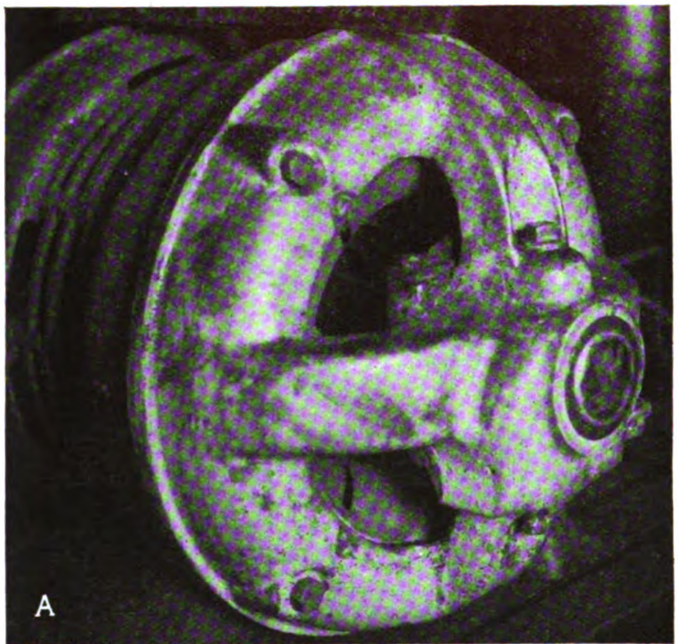
Old design with maximum possible improvements through addition of tightly closed oil ring slot by use of felt and steel oil ring slot cover at K screwed down.

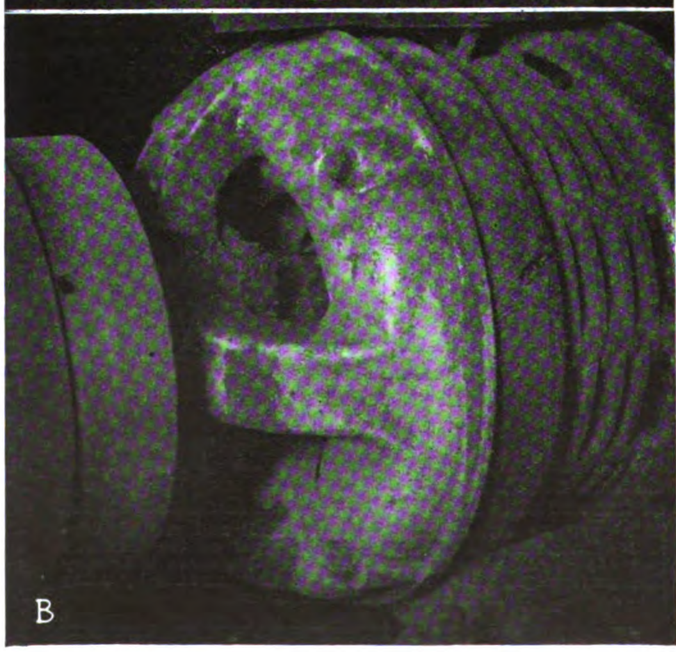
This partially corrects slopping out of oil and reduces current of air through the housing, indicated as troubles (3) and (4) in the upper lefthand caption. However, it is very difficult if not impossible to secure a tight joint at *D* by using a cover such as *K* held on by radial screws.

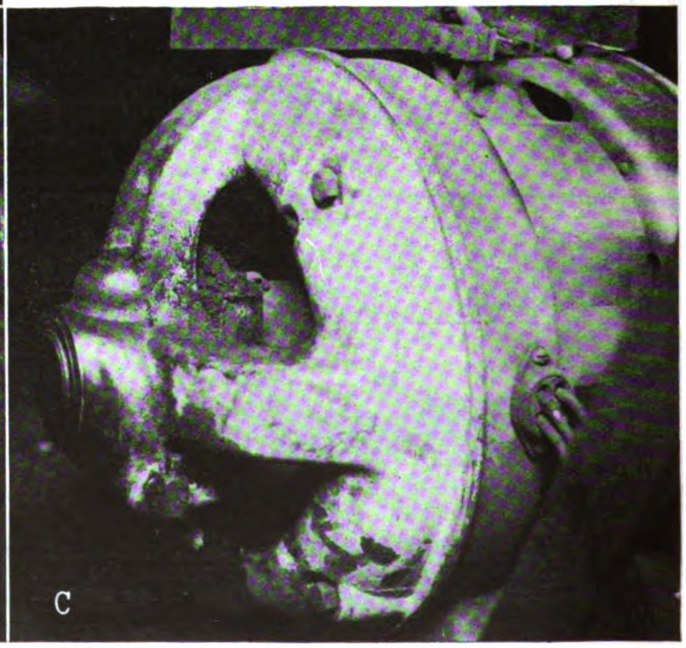
Inasmuch as this article is confined to electric motors and generators, we need not consider the item of friction losses in transmission, such as in lineshafting, which are admittedly very high where sleeve bearings are used and where proper alignment is hard to maintain. In the case of motors only two or three bearings need be considered, and these are either part of the motor itself or mounted on a common bedplate, which is an insurance for proper alignment. Furthermore, the small air gap makes it imperative that a good line-up be obtained. Hence, the friction losses become a matter of actual bearing friction not induced by mis-alignment. The sleeve bearing has a relatively high starting friction. However, this occurs only at the moment of starting, until an oil film is established, which requires less than one turn of the shaft. As the speed increases the friction coefficient drops rapidly, being only slightly in excess of what is found in ball bearings.

Bearing Surface.—Sleeve bearings, however, have the advantage of a large bearing surface, which is easily proportioned to take care of any load condition when designing the bearing. Thus, as in the case of geared or chain-driven applications, we know very closely the working load per square inch of projected bearing surface. Years of experience have established working factors so that we are in a position to base designs upon certain known factors, well proven and tried. The presence of the oil film forms a flexible or cushion element, suitable for absorbing shocks. The babbitt lining, after being "run in," conforms to the load conditions which may cause slight shaft deflections and shapes itself so as to distribute the pressure. Moreover, in some cases self-aligning bearings may be used, which readily present a uniform and large bearing surface to the load. This is quite in contrast to the point contact found in ball bearings, which is not yet fully understood when it comes to a matter of correct proportions regarding different classes of service, vibrations, and peak loads.

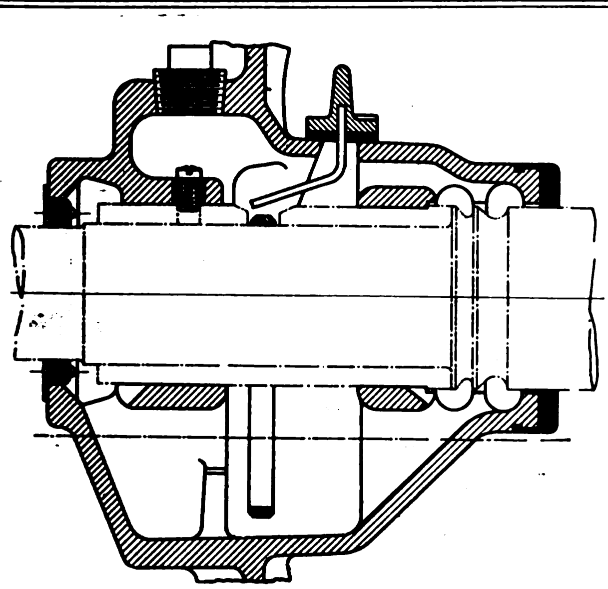
Wear.—No matter what type of bearing is chosen, wear is bound to occur. Then comes a time when replacement will have to be made. Sleeve bearings are easily replaced and if no spare is available, they may be rebabbitted, the process being an old one and understood by any good millwright or mechanic. Moreover, running clearances are well known and a slight error is not so serious a matter, since the oil film is capable of absorbing slight variations. Again, if a journal is loose, and "hammering action" due to the load conditions and vibration occurs, it comes upon a considerable area and not upon a point contact; hence it is not so harmful. It has been noticed in some installations that sleeve bearings were operating with clearances of 1/16 in. and over, due to wear. Operating under such conditions, of course, is not advisable but it goes to show that the period of usefulness to utter uselessness is distributed over a considerable length of time, which is an



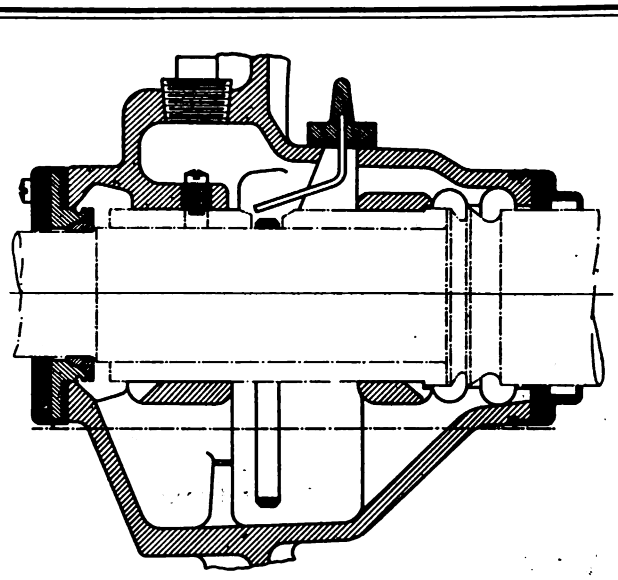




These three illustrations show leakproof bearing housings after a six months' running test without cleaning, as the dry dust adhering to the housings in the bracket arms shows. A is the front end of an 1,800-r.p.m. motor. B is the pulley end of an 1,800-r.p.m. motor, and C, the front end of a 3,600-r.p.m. motor. The construction of these bearing housings is shown in illustrations on the preceding page.



New design of housing that overcomes the five difficulties outlined as (1) to (5) on a preceding page.



New design with addition of leakproof devices to prevent leakage characteristic of motors running at high speeds.

important item in places where operation cannot well be interrupted from one end of the week to another. If trouble develops, it usually gives us signs long in advance of the actual break-down.

Replacements.—The matter of replacement is rather simple with sleeve bearings. Where gears or couplings are pressed on the shaft, split bearings may be used. Motor brackets are oftentimes designed in this manner, permitting removal of the bearing without dismantling the installation. This saves time. Where a middle bearing is used, the split sleeve bearing is the only alternative. Motor-generator sets with two rotors mounted on a common shaft and requiring a middle bearing, are easily taken care of in this manner. Outfits direct connected to turbines or blowers, particularly in places where space is limited, could hardly be made otherwise than with sleeve bearings. Split brackets are readily dismantled and the bearing removed without much difficulty.

Heating of the Journal.—Where loads are high and the pressure per square inch of projected bearing surface due to "dead load" is considerable, the sleeve bearing is without a parallel. Heating of the journal, if it occurs, can readily be cured by using gravity oil feed. The lubricant carries away the heat and can be cooled outside of the bearing. Practice has shown that water cooling is not required if the bearing is designed correctly and in many places where such a measure was originally installed it was never used and the journals have operated for years without water cooling.

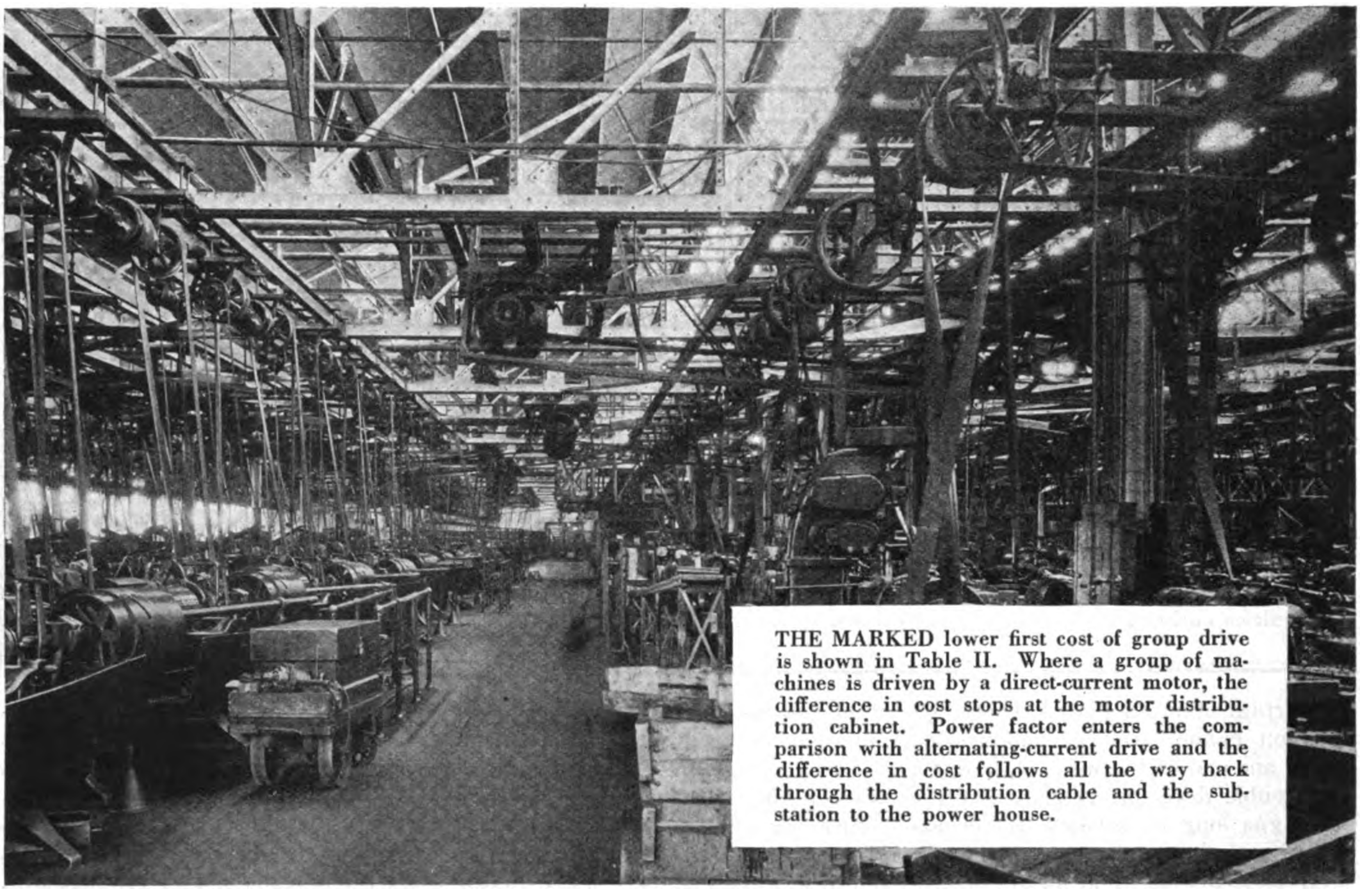
Stray Currents.—Another advantage found in sleeve bearings becomes prominent in cases where stray currents are found. The oil film assumes the role of an insulator to some extent, offering resistance to electric currents. Although this oil film is not effective to the extent of rendering the bearing immune to the passage of such currents the point contact, such as in ball bearings is avoided, thereby more effectively resisting the "pitting" found in some ball-bearing installations.

Handling Bearings. — Handling and manufacturing of the sleeve bearing is a process which can readily be taken care of in any well-equipped shop, without requiring extreme refinements and tolerances which are fractions of 0.001 in. This will be readily appreciated in repair work in the field, particularly in out-of-the-way places, where neither skilled help nor fine equipment is available. If it becomes advisable to carry spare parts the capital tied up is not great. Further, the handling and storing of sleeve bearings does not require unusual care and precautions. Babbitted bearing surfaces are not liable to become rusty, nor does the presence of particles of dust or dirt affect them. It is a simple matter to clean out all visible dirt.

Operating Temperatures.—Motors operating in very hot places are not so easily affected by temperature, since the liberal running clearances will permit a certain amount of expansion without influencing the operation. This point may seem somewhat far-fetched to some, but practice has shown that in cases of generators direct connected to steam turbines, ball bearings had to be made of special design to compensate for temperature; otherwise failure occurred. This trouble is foreign to sleeve bearings.

Initial and Operating Expense.—As to the matter of expense, the sleeve bearing is by far the cheaper. Initial cost could never be used as an argument against it. As to operating expense, objections are raised against the sleeve bearing principally on account of the damage caused by oil leakage. This feature, however, is not fundamental evidence against the sleeve bearing but evidence of some improper condition, in care or design or manufacture, which can be corrected.

Correct design and care are necessary, no matter what type of bearing is used; otherwise failure will occur. This is equally true of oil-ring sleeve bearings, waste-lubricated sleeve bearings, ball and roller bearings. While all of these types have a certain field, the oil-ring sleeve bearing undoubtedly meets the varied service required of the well-known, general-purpose, industrial-type motor. After all, it is a question of total expense, initial and operating, which should decide; and it has been found that by applying correct principles in the design of sleeve bearings and maintaining high standards of manufacture and maintenance, there is no other bearing which is so economical.



THE MARKED lower first cost of group drive is shown in Table II. Where a group of machines is driven by a direct-current motor, the difference in cost stops at the motor distribution cabinet. Power factor enters the comparison with alternating-current drive and the difference in cost follows all the way back through the distribution cable and the substation to the power house.

Service Conditions That Indicate

When to Use Group and Individual Drives

Together with Practical Operating Requirements and Supporting Data Developed from Long Experience in Mill and Factory Work

By ROBERT W. DRAKE

Electrical Engineer, McCormick Works, International Harvester Company, Chicago, Ill.

A DETAILED ANALYSIS of the reputed advantages of individual drives as compared with group drives will show that the latter have a much wider field of application than is commonly supposed. In the article by the writer in the February issue of INDUSTRIAL ENGINEER, the reputed advantages of individual drives were rather fully discussed together with the main features of applications wherein these drives are superior. In this article the reputed advantages of group drives are taken up and a comparison is drawn between the investment and operating cost of group and individual drives.

The lower first cost of group drive is very marked. With individual drive there is an increased cost due to the larger number of motors required and to the increased amount of wiring necessary. The cost per horsepower of motors, including controllers and branch circuit wiring, is likely to average, roughly, \$20 for group drive, to \$75 for individual drive.

THIS IS the second of a series of articles that analyzes in detail the advantages of group and individual drives. The first article appeared in the February issue and discussed fully the principal reputed advantages of the individual drive. In this article Mr. Drake takes up the principal reputed advantages of group drives. The third article of this series will discuss details of layout and operation of group and individual drives.

As was pointed out in the preceding article, from three to five times greater installed capacity is required with individual drive; hence the cost of this item for a given installation will be in the ratio of \$20 for group to \$225 to \$375 for individual drive.

There is also to be considered the difference in cost of the generating equipment. Where a group of machines is driven by a direct-current motor the difference in cost stops at the motor-distribution cabinet. Power factor enters the comparison with alternating current and the difference in cost follows all the way back through the distribution cable, the substation, to the power house.

The cost of generating and distributing equipment required to drive a motor horsepower is, with the exception of boilers, proportional to the amperes required by the load, not to the power required, and will vary from \$275 for horsepower of load operating at an average of 80 per cent power factor (well-planned group drive plant including lighting

load), to $340 for a horsepower of load having an inherent power factor of 50 per cent (average for a well-planned individual drive including lighting load).

Public service companies realize this fact even better than the power users who generate their own energy, and most large power contracts include a clause that increases the unit price for power when the power factor falls below 70 per cent to 80 per cent. Many contracts include a reduction of rate for power factors higher than that specified. When compared with such differences in cost of purchased power or with the fixed charges on generating equipment, the relatively small cost of the actual motors sinks into insignificance.

The above investment costs for handling an individually-driven load of low power factor assume that the power factor will be corrected by static or synchronous condensers, and include the cost of the necessary equipment. The writer believes that synchronous motors should be used wherever they are really suitable in either group drive or individual drives. It is exceptional to find suitable applications (without sacrificing reliability), for such motors, in sufficient aggregate capacity to bring the power factor of even a group-drive plant above an ideal figure of 85 per cent. Then, in the case of an individually-driven plant the additional power factor correction necessary to bring the average plant power factor up to the same figure represents an additional investment chargeable to power factor correction alone. This investment and the resulting fixed charges together with energy losses and maintenance costs are generally warranted in the case of a large, privately-operated system, or where power is purchased under a contract with a power factor clause. In the case of a small, privately-owned system it is cheaper to purchase non-standard generators designed for low power factor and install a heavier distribution system. Few plants consider the low power factor situation until the generators are bought and the plant is in operation; so synchronous or static condensers are generally in order.

The extra costs engendered by the inherently low power factor of an individually-driven factory are seldom recognized. If we charge these costs or the costs of the expedients necessitated to correct the low power factor against the individual drives, as is just, we have one of the strongest arguments for group drive.

Table I—Comparison of Motor Repair Costs

Motor Ratings	Cost of Motors, New	Cost of Rewinding	Cost of One Pair of Bearings for Each Motor
For one 50-hp. motor, 900 r.p.m.	$ 440	$ 250	$ 7.50
For five 10-hp. motors, 900 r.p.m.	900	550	20.00
For ten 5-hp. motors, 900 r.p.m.	1,400	830	22.00
For fifty 1-hp. motors, 1,200 r.p.m.	2,900	1,200	50.00

I. Principal Reputed Advantages of Individual Drive.

A. Elimination of overhead shafting and belting.
1. Lineshaft friction losses eliminated.
2. Maintenance of shafting and belting eliminated.
3. Cleaner shop.
4. Better light.
5. Closer speed adjustment of the tool to the work.

B. Location of machines to suit the continuity of a manufacturing process without regard to the location of lineshafting.

C. When only a small proportion of the installed machines is to be operated (e. g., overtime or slack season) it is not necessary to operate idle shafting and belting.

D. On large work the tool may be taken to the work instead of the work to the tool.

II. Principal Reputed Advantages of Group Drive.

A. General advantages.
1. Lower first cost.
2. Lower electrical maintenance expense.
3. Breakdowns with consequent delay to production less frequent.
4. Possible to standardize more fully on motor styles and speeds, with consequent possibility of carrying complete line of spares and resulting in greatly decreased delay from such breakdowns as do occur.

B. Particular advantages when using a.c. power.
1. Here the lower first cost extends back through the distribution system and to the power house.
2. If the power is purchased, this is reflected in a lower unit cost for power because of the greatly increased power factor attainable with group drive.

Group Drive Has Lower Electrical Maintenance Expense

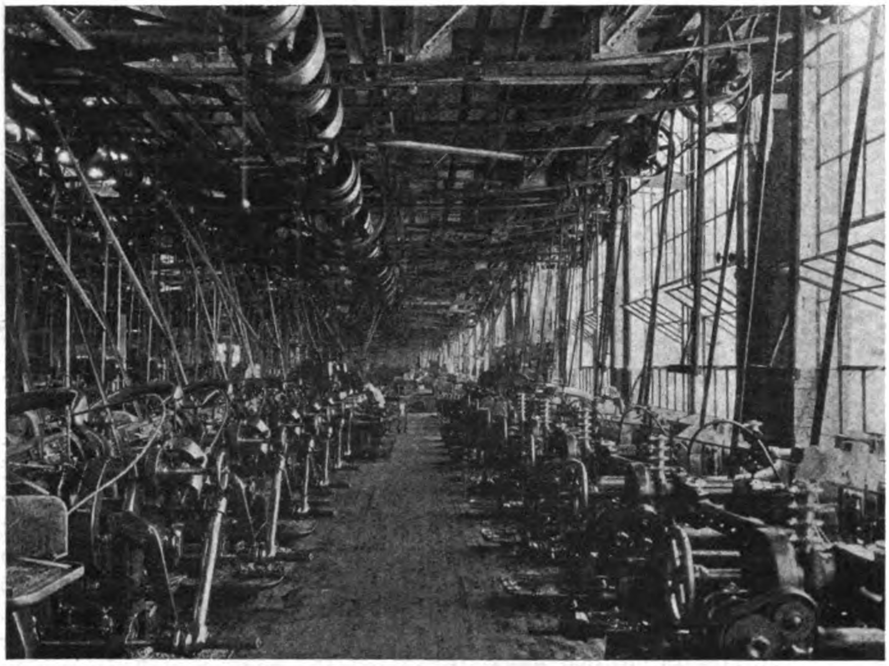
Routine maintenance and inspection of each small motor costs almost as much as for a large one. The cost of repairs does vary somewhat with motor size, but by no means in proportion to size. The comparison in Table I will bring this out plainly.

Now the number of repairs is far greater *per motor installed* for individual drive motors than for motors driving groups. This may seem surprising, for the individual motors generally do not run steadily; however, the fact is incontrovertibly demonstrated by experience and here are some of the reasons:

(1) If an extraordinary amount of power is demanded on an individually-driven machine by an uncommonly heavy job or by a machine adjusted too tight after overhauling, the motor is likely to "roast out." With a group drive the increased demand due to a few such machines will be much less per cent overload on the motor. It is very uncommon to have abnormal loads on all machines in a group occur simultaneously.

(2) The smaller sizes of motors, especially in the case of alternating-current motors, are far less rugged. On gear drives, many manufacturers furnish die-cast bearings which pound loose in the heads. Also, on the smaller motors used on individual drives there are partially-closed-slot windings which cannot be so thoroughly insulated from the core as is possible with open slot windings as furnished in the larger sizes usually applicable to group drive.

(3) In ordinary group-drive applications some trustworthy employee is delegated by the foreman to start and stop the motor. He can be taught, by very simple instructions, how to start and stop and what to do if the power goes off when machines are under load and the torque required to restart is beyond the capacity of the motor. Ordinarily a man will be selected who has been employed in the department for some years and such instructions once given need not be repeated at unduly frequent intervals due to labor turnover. In the case of individually-driven machines, everybody handles motors, the least intelligent as well as the most intelligent. The abuse which the motors get would be ludicrous, were it not so serious. Automatic devices offer the only protection possible against ignorance, but even automatic devices can-



Building construction and lighting are points to consider when selecting types of drives.

In manufacturing buildings as they are constructed nowadays, with walls that are all windows and with high ceilings, the shafting and belting necessary for an intelligently-planned group drive of 10 hp. to 50 hp. cannot be said to interfere seriously with either the natural or artificial lighting.

not eliminate such troubles. They only reduce them.

(4) Individual-drive motors are usually located where they are more exposed to accident than are group-drive motors, which are ordinarily mounted on the ceiling. Motors on the floor or mounted on a machine are more exposed to dust and dirt, which wear out the bearings. They require more frequent cleaning due to metallic and other conducting dust which works into the winding, causing grounded coils (especially on partially-closed-slot windings) and to water and to oil when these are present in the process. Foreign bodies such as metal chips, etc., are more likely to enter the air gap and "rip" the coils.

(5) Many individual drives are of necessity geared, which wears out bearings more rapidly than do belt drives. The life of bearings in belt drives under favorable conditions averaged eight years in one plant under my charge. With gear drives a life of that many months is not uncommon, and in one application six weeks service was all that we could realize with standard motors.

(6) Many individual drives are silent chain drives, which are excellent while the chain is in good condition. When one pin or pivot in the chain fails, however, the distance between teeth of the chain is increased at that point and each time this point in the chain passes around the motor pinion it strikes a hammer blow, the effect of which is astonishing. When it is necessary to continue such a drive in service for a few hours until noon or until shift-changing time, the motor not infrequently breaks down. If it runs through, the bearing shells are worn on the outside so as to be unfit for rebabbitting; the head is worn on the inside so that it must be replaced, since even a new bearing will be loose therein, and not infrequently the slot insulation is so worn at the end of the slot by the excessive vibration that a ground soon occurs.

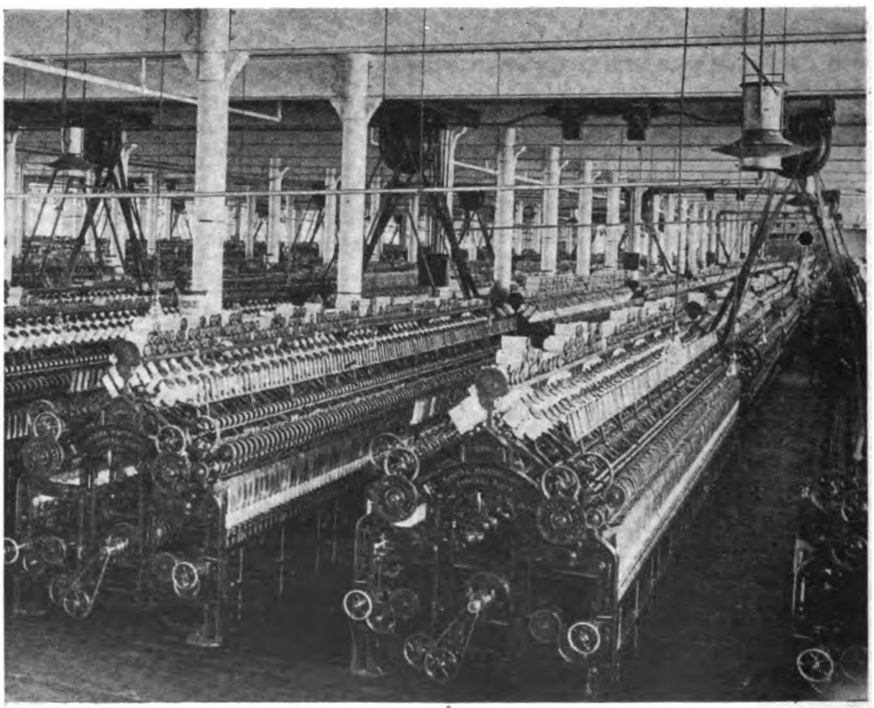
The cost of routine inspection of each small motor (individual drive) is substantially the same as the corresponding cost for a large motor (group drive). The writer's experience shows that it pays to have a motor inspector visit each motor every day. This matter is further discussed in the third section of this series of articles.

The cost of repairs for each small motor (as ordinarily installed for individual drive) will average higher than the repairs on a larger motor driving a group of machines in similar surroundings. The unit cost of bearings, rewinding, and the like, is somewhat less for the smaller motors, but for reasons explained above, the frequency of repair averages much higher and the total average annual cost of repairs per motor is considerably higher in the case of individual drive. For example, in two large industrial plants with which the writer is familiar, one principally group driven, and one approximately 50 per cent individually driven, with the class of manufacturing roughly similar and the total number of motors in each plant approximately the same, the total cost of motor repairs in the plant where 50 per cent of the motors are on individual drives is more than twice that of the group-drive plant.

The above comments give a rough idea of the relative cost of maintenance *per motor*. The relative *total* cost of motor and starter repairs is harder still to approximate because of the great difference in service conditions, such as the average number of machines per group, and their location which involves the relative liability to injury from flying chips entering the air gap, and so on. For average manufacturing conditions, I believe that it is entirely safe to state that in a plant where individ-

Group drive arranged without the use of lineshafting.

By the use of two pulleys on each end of the motor shaft four machines are driven in a group. This scheme combines the advantages of group drive with some of the advantages of individual drive.



ual drive is carried to an extreme the electrical maintenance expense for motors and starters will exceed ten times the corresponding cost for an intelligently planned group drive.

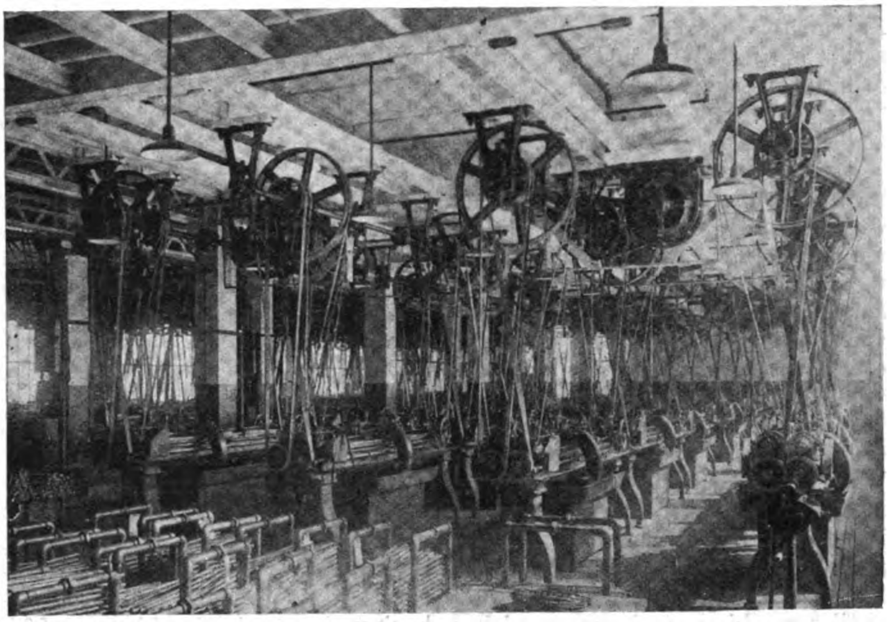
Before leaving this subject, let me call attention to the fact that the maintenance of motors alone is not the whole story The maintenance of shafting, pulleys and belting for group drives must be balanced against the saving in motor maintenance.

Reliability of Drives is an Important Consideration

The choice between individual and group drive in any given case should depend upon the total annual cost. However, the true relative total annual costs are not by any means approximated by the sum of interest, depreciation, taxes, insurance, power consumed, maintenance and repairs. Reliability is a factor which has an important bearing on total annual cost. In a large, highly-organized plant there are hundreds of drives whose temporary failure even for a few hours will interfere with the regular flow of production; there are dozens of drives whose failure for a few minutes means a loss per minute sometimes equal to the cost of the drive.

There are several ways of considering continuity of service. For applications where a few minutes' delay will cause large loss, the only certain insurance is duplicate units or connections with two independent sources of power supply. If loss will continue even though the remainder of the plant is temporarily shut down by failure of the electric power supply, duplicate units should generally be driven by steam, gas, Diesel, or gasoline engines. An example of the necessity for such standby service is afforded by pumps which supply the water for cooling blast furnace tuyeres, pumps for fire service and the like.

The next degree of insurance comprises drives which may be delayed for, say, one hour without undue loss. In many such cases in a highly-organized plant, delay for a working day means interference with flow of production; assembly, painting, packing, and even shipping will be interfered with. With skillful help well organized, and proper engineering on the original layout, such delays in connection with motor drives can be avoided by means of a reasonable number of spare motors and a reasonable stock of repair parts. Steel mills have been organized on this basis for years, but most industrial plants have not yet reached this point.



Different sizes of pulleys on the same shaft of a group drive will give several different belt speeds simultaneously.

Each machine in this room requires two widely different speeds which must be delivered at the same time. A group drive with different sizes of pulleys on the line shaft readily adapts itself to this condition. For an individual drive to obtain this result each machine would require either individual countershafting or gearing, or else more than one motor for each machine.

The first requisite is a spare motor identical and interchangeable with every motor in service. Spare coils, bearings, pulleys, pinions and the like are necessary for each spare motor, in order that a burned-out motor may be put into running order in as short a time as possible. There is always the chance that another identical motor may break down before the first is repaired and returned to spare stock.

The stock of spare motors required to fulfill the above conditions may be reasonable, or it may be prohibitively large, depending on whether rigid standardization has or has not been followed in purchasing motors. If the purchasing department is allowed to "shop around" and buy motors from a half dozen different manufacturers, if motors of various speeds, types or makes in the same horsepower are purchased, you may need half as many spare motors as motors in operation, which is generally out of the question. On the other hand, if after careful consideration one or at most two standard types and speeds of motor for each horsepower rating are selected and rigidly adhered to, even at the expense of some inconvenience in arranging a small proportion of the drives, the percentage of spares necessary can, in a large plant, be kept between 5 and 10 per cent of the installed motors. When a type of motor becomes obsolete and is no longer obtainable, it is necessary to purchase a spare with the first motor of each horsepower of the new standard. When a motor of an odd or "off-standard" speed is purchased for some special application a spare motor must also be purchased, unless the drive is unimportant. It is surprising how few odd motors it is necessary to have in a group-drive plant if a little ingenuity is used in devising expedients to avoid them. It may be claimed that it is not possible to bring a motor from a distant point in a big plant and install it on the ceiling on a group drive in one hour. To this I can only answer that in a plant under the writer's charge, having 500 motors aggregating well over 10,000 hp., the electrical department failed in this matter less than once per year on the average, before the war, and since the war with somewhat less skillful men (equally good foremen) the failures have averaged only 2½ per year. Most of these failures are due to two breakdowns occurring at widely separated points in one "trouble district" at the same time, to the occurrence of a second breakdown involving the same size and style of motor before repairs are completed on the motor first replaced, or to some similar cause.

The necessity for the immediate replacement of a defective motor is the exception rather than the rule.

Frequently the replacement of only a part is necessary, and quite as frequently the defective motor can be "nursed through," until a more convenient time for replacement.

Breakdowns with consequent delay to production are less frequent with group drive than with individual drive. This results partly from the factors discussed under maintenance and partly because the great variety of motor types and speeds in each horsepower required by individual drive makes it impractical to stock a complete line of spares, or even spares for all important drives. With group drive if one, or at the most two, standard speeds for each horsepower are adhered to, a complete line of spares is practical and it never becomes necessary to wait until a machine can be rewound before getting a drive back into production after a breakdown.

A quantitative comparison of the delays resulting from individual and group drives is outlined in the following paragraphs. This comparison is based on the two rooms of machines for which the investment and operating costs are given in Table II.

Group Drive.—Once in fifteen years a delay lasting less than one hour. Once in 200 to 500 years a delay serious enough so that it will last more than one hour, and the men will be sent home for the rest of the day.

Individual Drive.—Once every three months some machine is out of service for an hour or more due to motor or starter trouble.

Due to the great variety of speeds, styles and types of motors a complete line of spares is inadvisable. Consequently about half these delays result in a shutdown until the following day and, roughly, one-fifth involves a delay until a motor can be rewound. This may mean three days, or more if another rush rewinding job is ahead of it.

Table II—Comparison of Group and Individual Drive Costs for a Specific Installation

TOTAL COST OF DRIVES	GROUP	INDIVIDUAL
Cost of shafting, countershafts, hangers and belting, motors, starters, branch wiring and pro-rated cabinet cost, including installation and overhead	$ 4,985	$13,400
Power factor of motor load in room, average	80%	30%
Pro-rata cost of mains from substation or power house to cabinet. I am assuming a moderate sized factory employing say 3500 men. Mean length feeders from power house or substation bus to manufacturing rooms 600 ft., voltage 440	450	1,200
Proportionate cost of power house equipment to serve room, including cost of reserve capacity necessary to assure service, and proportionate cost of power factor corrective equipment required to maintain 75 per cent power factor	13,350	14,850
Proportionate part of investment in spares and spare parts for motors, starters, controllers, etc.	25	450
Total cost of above items	$18,810	$29,900
OPERATING EXPENSES PER YEAR	**GROUP**	**INDIVIDUAL**
Annual fixed charges on investment, interest, depreciation, insurance and taxes at 15% total first cost	2,825	4,490
Amount of coal burned or amount of energy purchased	......*	......*
Maintenance and repairs of belts, including belt replacements	$ 225	$ 25
Maintenance and repairs of shafting and countershafting	75	......
Maintenance and repairs on pinions, chain, etc.	......	60
Maintenance and repairs of motors, starters and wiring	57	345
Maintenance and repairs of power factor corrective equipment	......	10
Cleaning lamps and reflectors	30	15
Window washing	15	10
Painting room inside per year (pneumatic paint machine)	20	8
Grand Total (fixed charges plus operating costs)	$3,247	$4,963

*This is essentially the same for either installation as shown on page 59 of the February issue. The lower motor efficiency with individual drive offsets the lineshaft and belt losses. If one or two machines are only occasionally operated overtime alone, the annual losses in the power-factor-correcting equipment necessitated by individual drive will offset the overtime lineshaft and belt losses of the group drive.

Above I have discussed in a qualitative way, the relative advantages and disadvantages of group and individual drives. Each has its field where it is generally admitted to be unwise to attempt to apply the other.

There is a large middle ground where many installations of each sort have been made. To make the discussion clearer in some respects, I will give an approximate estimate of the total annual costs of operation for one manufacturing room, group driven, and for a room containing the same machines individually driven. It is useless to attempt any precise estimate of quantities for this purpose, for conditions vary with every industrial establishment and precise costs deduced for one plant are not always applicable to another. All that I hope to accomplish is to give a better idea of the relative importance of the various items which have entered into the above discussion.

I have chosen a room containing machine tools used in the production of rather accurate parts, interchangeable manufacturing, of course. This room contains twenty-three machine tools which can be driven in a single group requiring a 40-hp. motor, or they can be driven by twenty motors driving individual machines and one motor driving three machines. In the following comparison (Table II) all items which are substantially equal for the two drives compared have been omitted.

This comparison shows a difference in annual operating expense of $1,700 in favor of group drive. Inasmuch as there are twenty machines that can be individually driven, this annual difference amounts to $85 per machine per year. On at least half the machines in the room individual drive could not help in any way to increase output. Thus on the other ten machines, individual drive must save the equivalent of $170 per machine per year to justify complete individual drive of all of the machines compared.

In this particular case the logical solution, in my opinion, is individual drive for those machines where it will result in a real gain in output, with group drive for the remainder of the room, but in two groups, one small group being separate, since in this vicinity the handling of the work dictates the location of three machines which may be expected to work overtime during rush seasons.

How to Check Up On Insulating

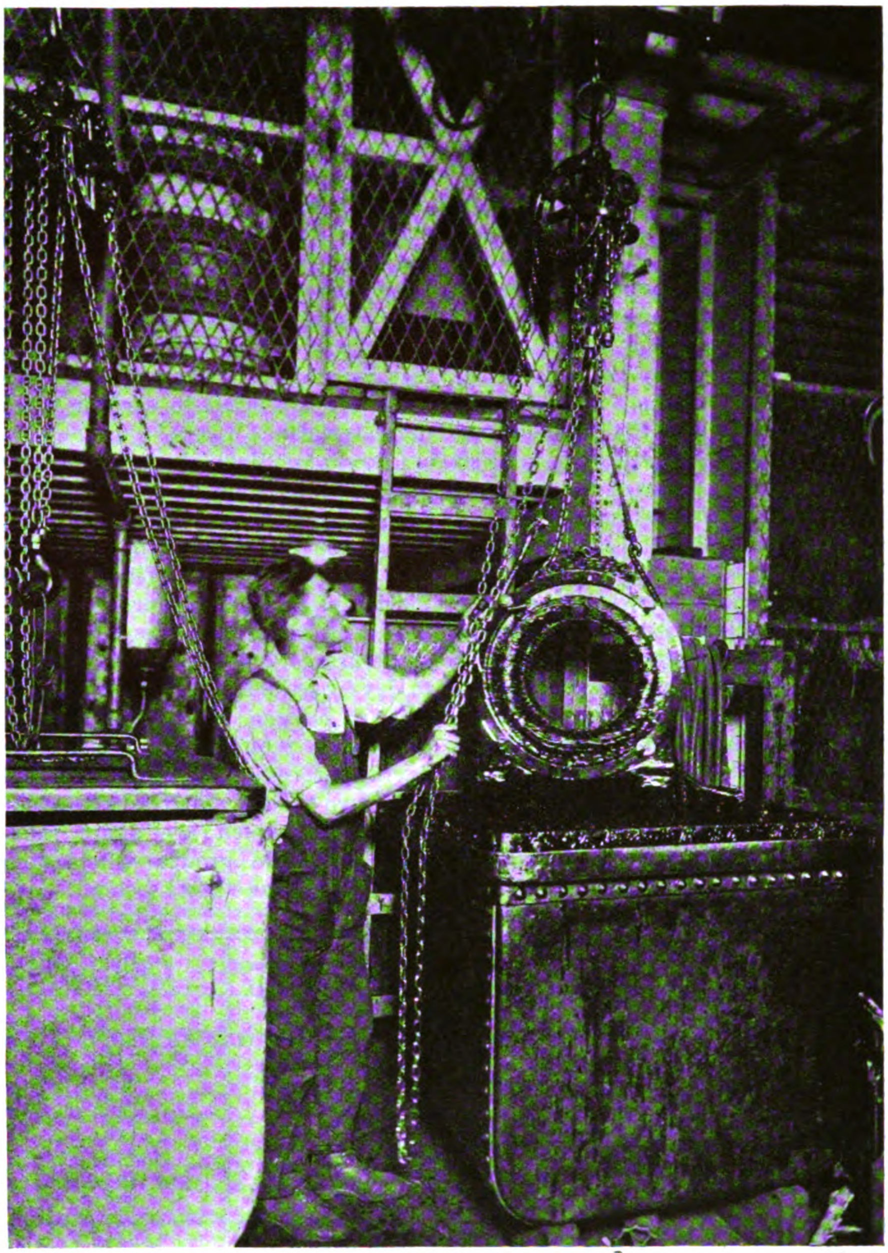
Varnishes and Their Solvents

To Make Sure They Are Suitable for Coils and Windings and to Know When They Are Properly Applied

MR. HAZELTINE GIVES these practical suggestions and the reasons for them:

Keep the varnish tightly covered when not in use. Buy a hydrometer and use it. Determine the specific gravity at which the varnish works best for a particular job. Then take readings of the gravity every day before you start to use it and add thinner when necessary to keep the varnish at the proper consistency. When thinning be sure that varnish and reducer are at the same temperature. Add thinner slowly and stir it thoroughly all the while. When cold thinner is added too rapidly it is liable to throw the varnish base out of solution. Large quantities when put in too quickly often cause a like result. Warmth aids the union; hence it is better to have the varnish and the reducer at a temperature of between 70 deg. F. and 90 deg. F. After the thinner has been added, stir until properly mixed. There seems to be an impression that repeated thinning destroys the qualities of the varnish. This is not true. Remember it is the base of the varnish that gives you the insulation. The base does not evaporate. When adding thinner you are simply replacing that which has disappeared.

This is the first of a series of articles on insulating varnishes. The second article will take up varnishes and the equipment needed for application; the third, varnishes and their troubles; and the fourth, selection of varnishes.



By H. L. HAZELTINE

Engineer of Insulation, The Sterling Varnish Co., Pittsburgh, Pa.

THE INSULATION of electrical apparatus has always presented to electrical engineers and those in charge of repair work, many perplexing difficulties. If it were simply a matter of protecting windings against electrical stress, grounds or shorts, the solution would be comparatively simple. The fibrous covering, such as cotton or silk, over the conductors keeps them separate and provides a space sufficient to prevent any electrical breakdown as long as the covering remains dry. Unfortunately, however, this fibrous covering has a great tendency to absorb oil, water and moisture from the air. These substances draw in with them actually conducting ingredients, such as carbon dust, which soon provides in service a direct path for the passage of the electric current. Also in the winding of coils this fibrous insulation is often pushed to one side, thus bringing the conductors too close together and oftentimes into actual contact.

Furthermore, in moving parts such as motor armatures, the coils must be held rigidly in place in order to keep them from being thrown by centrifugal force. Wedges driven into the slots are not sufficient, particularly to prevent the throwing out of the commutator leads and the loosening of the coils at the pinion end.

It is evident that a liquid material which will penetrate the interstices of the windings, and upon drying will provide a coat impervious to the

action of moisture, oil, acids or alkalis, and be sufficiently hard to prevent the passage of hard particles of conducting materials, such as carbon or metallic dust, would be ideal. This is the function of insulating varnish.

Insulating varnishes have been for many years universally used in the construction of electrical machines and it seems strange that so little authentic knowledge concerning them is possessed by the men in actual charge of their application. They are indeed so little understood that the user often regards varnish as the cause of many of his troubles. In fact, varnish makes an excellent scapegoat for defects in insulation. The manufacturer (who has the only first-hand knowledge of his product) will advise to the best of his ability, and yet his information is often regarded with suspicion.

Nevertheless complaints, made in good faith, are received occasionally which show the vague general knowledge concerning this class of material. For example, one manufacturer of motors writes: "The black varnish we are using does not give any color on the coils." Investigation showed he had emptied a drum of thinner into his varnish tank and forgotten to stir it. Another wrote: "The varnish eats holes in tin," although it had been stored and shipped in ordinary tin cans. Another inquires as to the varnish to use on 9,000 volts service—nothing else being specified.

It is the purpose of this series of articles to clear up these misunderstandings and to assist the user in a more intelligent selection and application of insulating varnishes.

Varnish is a combination of drying oils, gum, drier and solvent. An insulating varnish may, therefore, be defined as such a combination of drying oils, gums, driers and solvents as to be a high dielectric, wet or dry, both in ohmic resistance and disruptive strength. Its solvent before evaporation should answer the same requirements. The coating once applied and dried should be adherent, binding and mechanically strong. Furthermore, it should not lose either its electrical or physical qualities when subjected to the continued action of heat and electrical stress—developed by the machine itself—combined with the action of acids, alkalis and moisture which may be present in the surrounding environment. It should be remembered that the function of insulating varnish is largely a mechanical one. It is a general axiom in electrical work that if we correct mechanical difficulties, the electrical ones will take care of themselves.

It is very difficult to make an absolutely definite classification of insulating varnishes. The distinction between the classes is vague and there are many cases of overlapping; hence any grouping which we make must be regarded as purely arbitrary and for the purpose of pinning our attention to certain types of materials.

Classes of Varnishes.—Insulating varnishes may be divided into two broad classes: (1) Those which dry by simple evaporation of the solvent. (2) Those which after the elimination of the solvent harden by reason of a chemical change in the structure. Such products are said to dry by oxidation, that is, the presence of oxygen, or air containing oxygen, is required throughout the drying process. These classes fall into two color subdivisions—clear and black—which are again separated into two groups—air drying and baking—as shown below.

INSULATING VARNISHES

OXIDIZING VARNISHES
- *Clear*
  - *Baking*
  - *Air Drying*
- *Black*
  - *Baking*
  - *Air Drying*

NON-OXIDIZING VARNISHES
- *Clear*
  - *Baking*
  - *Air Drying*
- *Black*
  - *Baking*
  - *Air Drying*

This grouping has its faults since it is quite obvious that some air drying varnishes may be baked and that almost any baking varnish will air dry if given sufficient time.

Another classification could be made according to the nature of the vegetable oils used in the manufacture of the varnishes. The principal oils are linseed and chinawood. There has been much discussion in recent years as to the relative merits of these two materials, and many extravagant claims have been made for varnishes containing the latter oil. It is not our intention to take sides but we will endeavor to point out the characteristics of each oil.

It is true that chinawood oil dries more quickly and requires the presense of a lesser amount of oxygen than does linseed oil. It will even dry under water and this characteristic has been the basis for the claims that the oil dries by polymerization, that is, by a readjustment of the structure of the molecules entering into its composition, and not by the absorption of oxygen. However, it must be remembered that water contains a certain quantity of free oxygen and this undoubtedly acts upon the oil and causes it to dry. Furthermore, if the statement were true, chinawood oil varnishes would not skin over on the outside but would dry uniformly throughout. This has not been our experience. We have found that a skin forms during the drying leaving a certain amount of undried varnish underneath and this has also been the experience of others.

Equally good varnishes can be made with either oil, but aside from the quicker drying of the chinawood oil there is no characteristic which makes it superior to linseed oil. It must be remembered that many so-called chinawood-oil varnishes contain only enough wood oil to render possible the use of the name. Furthermore, it must be remembered that a greater percentage of gum, particularly common rosin, may be used in their manufacture. This of course results in a more brittle product. It is a question whether the rapidity of the drying of the chinawood-oil products is due to the excess gum or the nature of the oil.

In general, the quicker the drying of any varnish the shorter is its life when exposed to operating conditions where it is subjected to continued heating and cooling and the vibration of the machine itself. Again, chinawood oil is a product of foreign manufacture and hence we are unable to control either the price or its purity. Linseed oil, on the other hand, is a more nearly native product and its purity can be very closely regulated.

We could group varnishes according to the percentage of drying oil contained. You have doubtless heard the expression, "long oil" or "short oil" varnishes. A varnish is said to be long in oil when the amount of oil contained is large in comparison

with the amount of gum. When this condition is reversed, that is, when the material contains a large amount of gum and a small amount of oil, it is said to be short in oil.

In the clear, or transparent varnishes, rosin is the commonest gum used. This gum is naturally a very brittle substance and hence varnishes containing large amounts of it have a tendency to become brittle and crumble. Black varnishes are, generally speaking, less oil resistant than are the clear varnishes, but they are much more proof against water and acids. Their color is derived from black gums. These gums are usually more flexible than those used in the clear materials; hence they will generally withstand continued heating better.

What is Meant by Life Tests.—There has been a demand occasionally for materials that will withstand so-called "life" tests. These tests are made by coating paper or cloth with varnish and baking in an oven until the film cracks when the sheet is bent about a mandrel of a given radius. The number of hours required before the material cracks is a measure of the "life" or the "flexibility" of the varnish. The demand has been for materials that will stand this test for several days, and even weeks. To obtain the results desired, the manufacturer has reduced the amount of drying oil and increased the percentage of gum, using very soft pitches for this purpose. Varnishes having great length of life have even been made with no oil at all. They are simply solutions of the soft pitch in suitable solvents. They would be classed as non-oxidizing varnishes, inasmuch as they dry solely by the evaporation of the solvent.

It is a peculiar thing that although such materials stand up very well on laboratory tests for flexibility, as described above, they do not stand up in service as well as the long-oil products do. It seems that machines in operation are subjected not so much to a constant heat as to repeated heating and cooling, and also to considerable vibration. The short-oil products, or those containing no oil, are dried out in service and pounded by the vibration until they pulverize, whereas those long in oil do not show this characteristic. They seem to have the ability to stretch with the expansion and contraction of the metal in the machine, and because of this are not affected by the vibrations. We call this quality "elasticity" to distinguish it from "flexibility" or "life." It cannot be determined by test but shows up only in service.

The pitches used in the non-oil products are similar to the solid compounds which are sometimes used for the filling of coils. These solid compounds are brought to a liquid state by heat and then applied to the windings. As they cool they solidify, but of course will resoften when subjected to heat. Hence, varnishes consisting of a solution of these products will soften and show a decided tendency to flow when exposed to the heat developed by machines in service.

Points on Long-Oil and Short-Oil Varnishes.—Let us now make sure that we have these facts straight as far as we have gone. Long-oil varnishes, either clear or black, are strong and adhesive. They have considerable "elasticity" and will withstand much vibration without crumbling. Short-oil clears have little "elasticity" or "flexibility." They require a short bake and are very strong mechanically. Short-oil blacks, on the other hand, have little "elasticity" but maximum "flexibility." They have little binding power. Both of the last two types show a decided tendency to soften and flow under heat, a characteristic which is, in many cases, objectionable.

Air-drying varnishes are generally those containing very little oil. Oftentimes they are simply solutions of solvent and gum. If they do contain oil there is so little present that they can be said to dry by the simple evaporation of the solvent. They have little strength, flexibility or elasticity and are used mainly for finishing where added protection is needed against external conditions such as oils, acids, water or alkalis. Generally speaking, the faster the varnish dries the more brittle is the final coating.

Table I.—Information needed to know when a thinner has a "narrow cut." See Fig. 1.

DISTILLATION RANGE OF STERLING REDUCERS.

TEMPERATURE IN DEGREES CENTIGRADE.	PERCENTAGES DISTILLED OVER					
	Reducer F. 181	Reducer F. 160	Reducer F. 149	Reducer F. 50	Reducer F. 100	Reducer F. 75
45°						
50°	1st. Drop.		1st. Drop.	1st. Drop.		
55°						
60°	1%		2%			
65°						
70°	4%		4%	1%		
75°						
80°	9%		10%	3%		
85°						
90°	21%		18%	7%		
95°						
100°	37%		32%	13%		1st. Drop.
105°						
110°	58%		48%	23%		4%
115°						
120°	71%	1st. Drop	65%	38%		15%
125°						
130°	81%	5%	75%	56%		33%
135°		24%				
140°	88%	69%	85%	81%	1st. Drop	49%
145°		89%				
150°	92%	94%	93%	94%	9%	68%
155°		97%				
160°	94%	98%	95%	95%	48%	80%
165°						
170°	96%		96%		72%	89%
175°				97%		
180°	97%		97%		86%	93%
185°				98%		
190°	98%		98%		92%	96%
195°						
200°					95%	97%
205°						
210°					97%	98%
215°						
220°					99%	
225°						

We have discussed so far the drying oils and gums used in the manufacture of varnish. There remains only a discussion of the solvent. This material is merely a vehicle used to spread the oils and gums uniformly over the surface or to carry these products, which provide the real insulation, into the interior of the coils. Once the varnish has been applied the solvent's function is over and it passes off into the air. Hence, in the drying of any varnish the first action is to drive off the solvent and the second is to oxidize the base, consisting of oils and gums, to produce a hard film.

It is obvious that the varnish should be supplied by the manufacturer at such a consistency and viscosity that its uniform application is easy, and that it should contain the least amount of solvent consistent with this. In other words, it should have the largest amount of base, or useful material, that is, oil and gum.

When the varnish is kept in open or partially-closed dipping tanks the solvent evaporates and must be replaced before the loss becomes too great. Otherwise the material becomes so thick and viscous that thinning becomes a very difficult, if not an impossible, task. It is sometimes found that after a varnish has been repeatedly thinned, it seems to flow more and possess less covering and filling powers, although having the proper gravity. It may also require a longer drying period. This is probably due to using a thinner with too wide a cut. The lighter fractions or chemical constituents have slowly evaporated leaving only the heavier ones. A point may thus be reached where the varnish at a given gravity does not possess the amount of base desired. When such a condition arises it is advisable to allow still more thinner to evaporate and use the varnish at some heavier gravity that trial shows will give the desired coating and consequent protection.

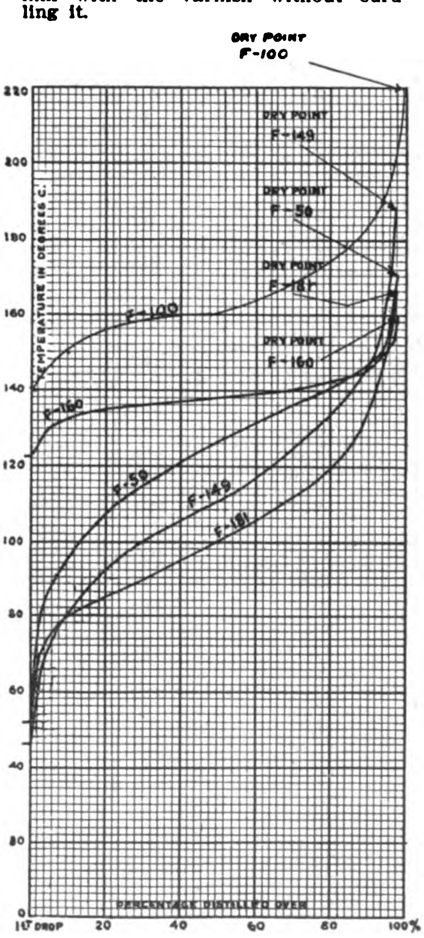
How to Select Thinners.—It is best in selecting a thinner to choose one having characteristics as nearly as possible like that used in the original varnish. Uniform petroleum distillates, such as benzine and petroleum spirits, are becoming more and more difficult to obtain and it is better to buy such products on specification. They should have a narrow cut, that is, they should contain no fractions distilling at either very high or very low temperatures. They should be free from paraffine, grease, or heavy oil, and should mix with the varnish without "livering" or curdling it.

Table I illustrates the meaning of the term "narrow cut." The curves shown in Fig. 1 are plotted from the values in Table I. These reducers having the flattest curve have the narrowest cut. Any reducer having a characteristic curve similar to these is suitable for varnish, provided it is of the same type as that used in the fresh varnish.

The apparatus, and its arrangement, used in the determination of these characteristics is shown in Fig. 2. The flask used is of the regular Engler type, with the side tube at the middle of the neck. Its capacity should be at least double the quantity of the liquid distilled. The side tube should be extended into the condenser where the water comes into contact with the inner tube. The thermometer is placed so that the mercury bulb is just even with this side tube so as to record the temperature of the vapor as it passes into the condenser. When one is also placed in the liquid it records a degree or two higher. The test is run as follows: Measure 100 cubic centimeters of the material to be tested in a graduated cylinder and then pour it carefully into the distilling flask. Use the same graduated cylinder to receive the distilled solvent. Place the flask in position upon a wire gauze and regulate the flame so that it just touches the gauze. As soon as the first drop falls into the receiving cylinder, record the temperature and so regulate the flame that the distillation goes on at the rate of about two drops per second. Then note the quantity in the receiver when the next 10 deg. point is reached on the thermometer, and for every 10 deg. thereafter. For example: If the first drop falls at 64 deg. C., the next reading should be made at 74 deg. C., and so on. Continue the distillation until the point is reached where the last drop is vaporized, indicated by a puff of white vapor in the bottom of the flask.

Fig. 1.—Curves plotted from data given in Table I.

The thinner with the flattest curve has the "narrowest cut." This means that it contains no constituents that distill at either very high or very low temperatures. It should also be free from paraffin, grease or heavy oil and should mix with the varnish without curdling it.

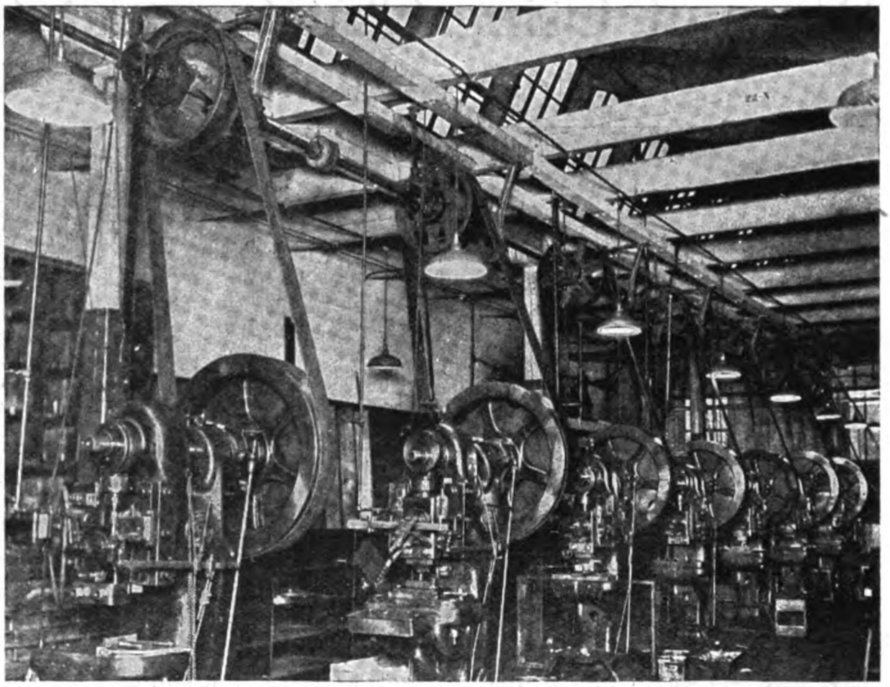


The solvents generally used in insulating varnishes are petroleum distillates (such as benzine and petroleum spirits), coal tar distillates, and turpentine, or a mixture of these. Wood or especially-denatured alcohol is also used to a certain degree. In the curves shown in Fig. 1 the one marked F-181 is the distillation curve for pure 62 deg. benzine; that marked F-160 is for coal tar distillate; F-149 is a combination of the two, 85 per cent benzine and 15 per cent coal tar distillate; F-50 is a combination of the two in equal proportions; F-100 is the curve for petroleum spirits.

Benzine (F-181) has already been partially described. It has the lowest solvent powers of any of the materials mentioned. On this account and because of its rapid drying, varnishes containing this solvent are especially adapted for use with enameled wire.

Petroleum spirits (F-100), sometimes known as turpentine substitute, has greater solvent powers than the lighter distillates. Its flash point is over 100 deg. F. and for that reason it is not dangerously inflammable at ordinary room temperatures. Inasmuch as it evaporates much more slowly than benzine, varnishes containing it are characterized by a smooth, even flow of the film and by great penetrative powers. Also, because of this the solvent does *(Continued on page 156)*

DURING THE past year there has appeared in INDUSTRIAL ENGINEER a series of articles dealing with problems associated with the installation and operation of mechanical power transmission equipment. These articles have covered belts, pulleys, silent chains, gears, speed reducers, rigid and flexible couplings, and friction and magnetic clutches and cutoff couplings. This article, which is a continuation of the series on clutches and cutoff couplings, takes up the information necessary when ordering and installing them and the operating conditions which are the most favorable. The purpose of this group of articles has been to present current practice in connection with the construction and application of the various mechanical power transmission elements and particularly to emphasize results possible when these problems are given more thought and care.



This battery of punch presses is driven directly from a lineshaft through individual clutch pulleys for each machine.

Ordinarily, unless countershafts are used, it would be necessary to operate the flywheel of the punch press continuously, even though the press were idle. With these friction clutches for each machine on the lineshaft, countershafts are eliminated and it is possible to cut out any number of presses and eliminate all friction losses except those due to the lineshaft and to the presses operating. Also, with such an arrangement as this, it is not necessary to start the driving motor under load, as all the presses can be thrown out at the friction clutches.

Practical Points To Consider When

Operating Clutches and Cutoff Couplings

So As to Obtain the Service Expected Without Interruption of Production

By FRANK E. GOODING
Associate Editor, Industrial Engineer

CLUTCHES and cutoff couplings, as pointed out in an article in the January issue of the INDUSTRIAL ENGINEER, are used for temporary or intermittent disconnections of sections of shafting machines or other equipment when it is desired to save the power loss which would occur if they were permitted to operate continuously. While the previous article covered their construction and application, this article will take up some of the practical points connected with the specifying, installation and operation of friction clutches and cutoff couplings.

Probably the most important consideration is to obtain a clutch or coupling of the proper size for the load. Equipment too small for the load is no doubt the greatest single cause of trouble. Friction clutches and couplings are rated, like flexible couplings, according to the horsepower they will transmit per 100 r.p.m. However, the total load of the clutch should be figured to include all possible overloads. For example, if a clutch is connected into a pulley driving a machine normally requiring 10 hp., but which may have a 50 per cent overload, the rating of the clutch should be at least 15 hp. to assure freedom from trouble.

Perhaps the most severe load on a clutch is given by the pulsations of a single-cylinder gas engine. This ordinarily requires a clutch with twice the normal engine rating per 100 r.p.m. Other severe service is in connection with stamping mills, punches, shears, mixing machines, pulverizing and grinding mills, rubber rolls, and other similar machines. One manufacturer recommends the following increases in rating because of the service requirements:

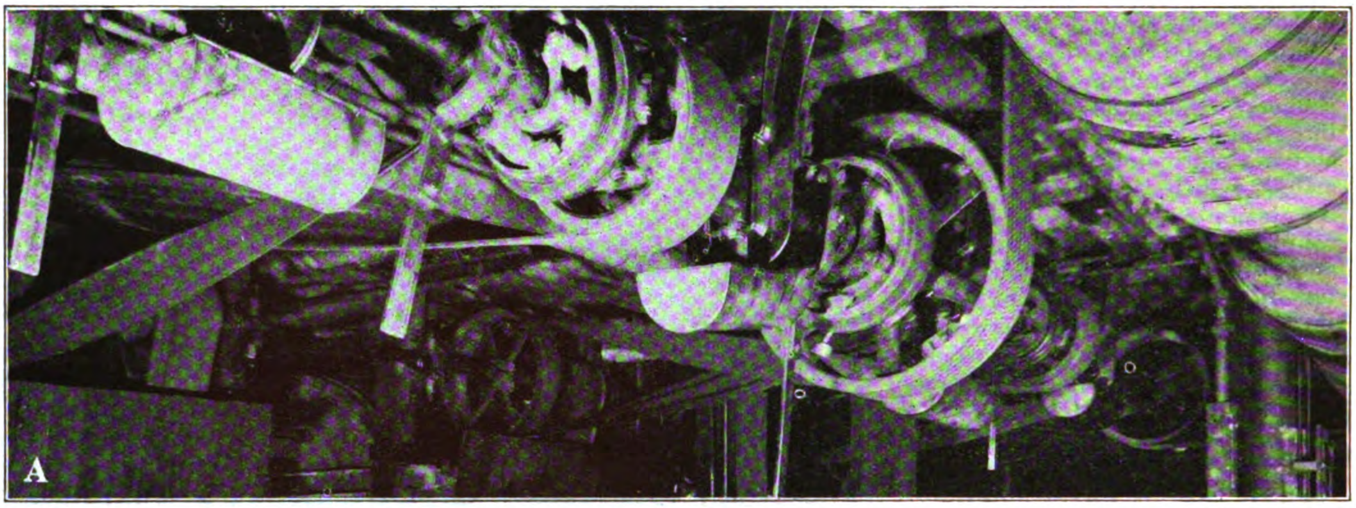
For single-cylinder gas engines, double the rated capacity of the engine, based on the same speed; for two-cylinder gas engines, add 50 to 75 per cent to the engine rating; for three-cylinder gas engines, increase 25 to 50 per cent in rating; for engines with four or more cylinders, an equal rated capacity.

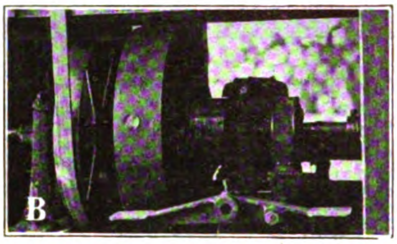
Where clutches are attached directly to the engines the above conditions must be adhered to but where attached to driven or receiving pulleys, a slight reduction in capacity is permitted. In case of doubt it is well to consult the manufacturer of the clutch who will advise from his experience.

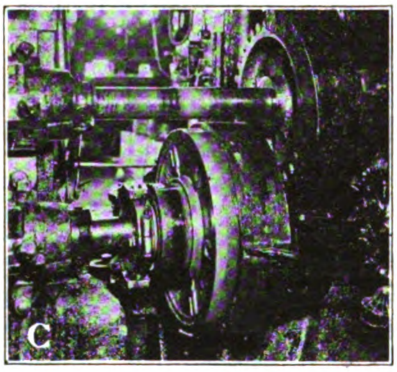
Any service where the movement of shafting is not continuous is out of the ordinary and in selecting clutches conditions must be analyzed carefully and a clutch of sufficient capacity provided. Some of the special considerations are found in connection with a clutch which is re-

Ways of Using Clutches and Cutoff Couplings

Nine Applications of Friction and Magnetic Units







A—Here clutches enable the entire line-shaft as well as individual machines to be cut out when not required without shutting down the whole plant or continuing to operate with heavy friction losses.

B—Foot-operated clutch and brake.

C—A guarded clutch on a heavy machine.

D—This large press is tripped through a clutch attached to the flywheel.

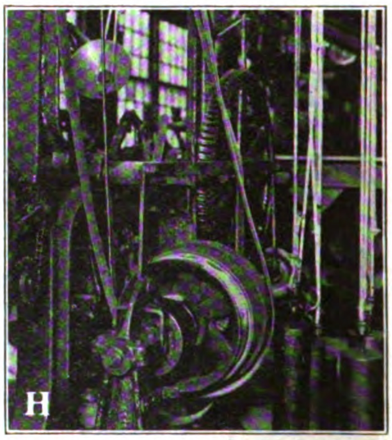
E—A clutch installation in the driving mechanism of a paper machine.

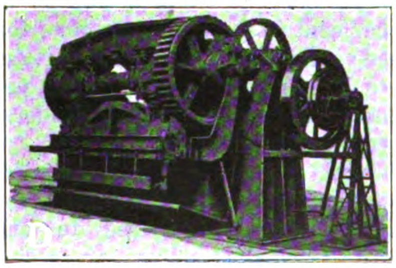
F—Totally-enclosed, cut-off coupling on a lineshaft driven by silent chains.

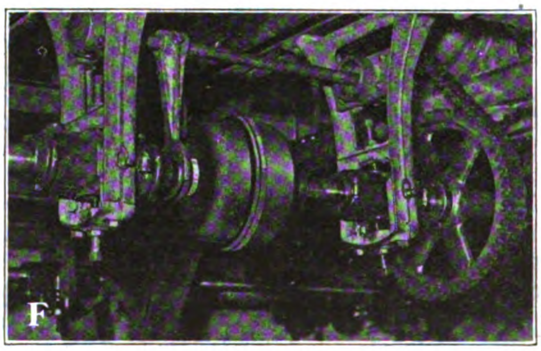
G—Many large presses are set in motion through a friction or jaw clutch.

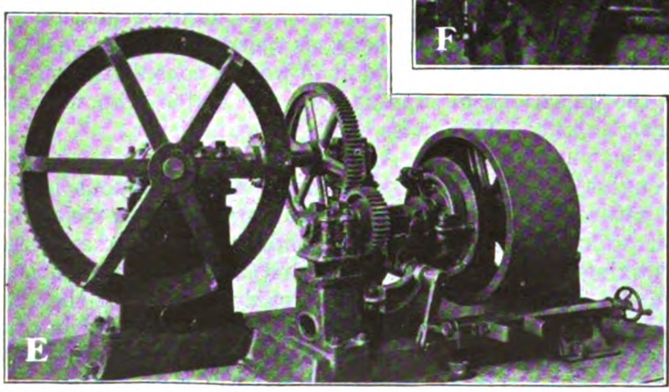
H—A clutch with lever trip for starting and stopping.

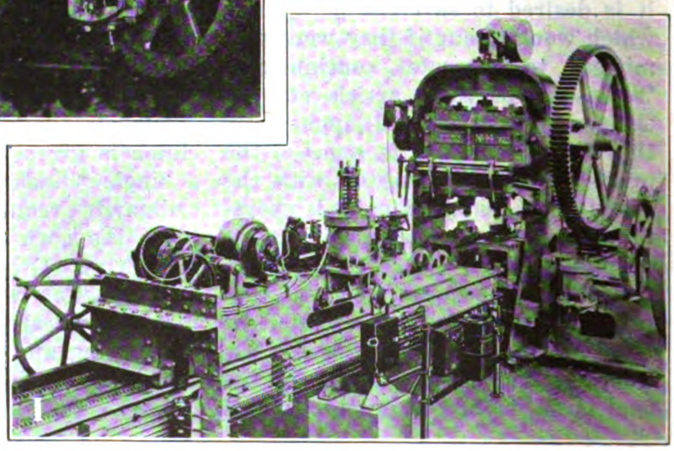
I—Here a 10-in. magnetic clutch is used in controlling one of the automatic motions of a spacing machine.

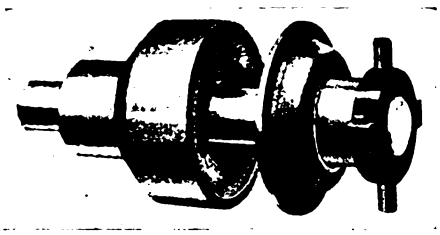












An example of the expanding-ring type of friction clutch.

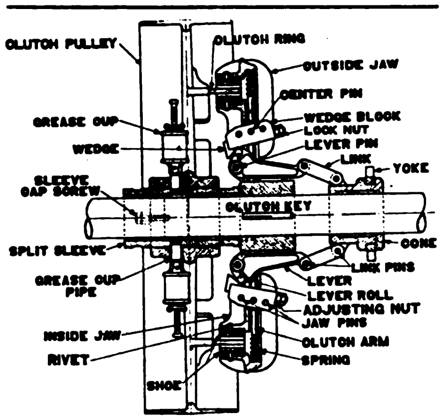
This clutch consists of a combined clutch casing and sleeve which rides free upon the shaft and upon which the pulley, gear, sprocket, or similar member is fixed. Within the casing is an expanded ring, which is keyed to the shaft, and makes frictional contact with the inner surface of the casing when expanded by two floating steel fingers and floating pins located within the ring. An oil and dust-tight cover encloses the clutch mechanism.

quired to start heavy masses from a state of rest; for instance, heavy flywheels, armatures and centrifugal separators. Also, large clutches must be provided to meet the conditions incidental to the operation of pumps, air compressors, and machines that are often started while under load, as saw mills, rolling mills, crushing plants and other similar machines. Because of the increased friction and heat, it is also advisable to use clutches of increased capacity when conditions require high speed or frequent engagement and disengagement. Perhaps the best general rule to apply in the selection of a clutch is to use one with the full rated capacity of the pulley to which it is connected at the rated speed, or of a double belt of the proper width for the pulley. Another reason for installing a clutch of the full rated capacity of the pulley which it may be called upon to drive, is that manufacturers frequently under-specify the power required to drive their machines and also when connected to a group of lineshafting, in particular, additional or larger machines may be added at any time. For this reason, for a lineshaft cutoff coupling it is always well to install a coupling of the full capacity of the lineshaft. It is also advisable when figuring the horsepower rating of a friction clutch or coupling, to take into consideration the effect of suddenly applied loads and the running speed, rather than simply the power transmitted through the clutch when engaged. Obviously, there is much more slippage when engaging a clutch on a fast-running shaft than on a slow-speed shaft. This, of course, affects the life of the friction surfaces.

To obtain the proper bearing surface on the shaft and to eliminate a twisting torque it is always advisable to see that the bearing or sleeve is at least 1¼ times the width of the connected pulley.

In ordering clutches, clutch pulleys and cutoff couplings, or asking for an estimate, it is well to give the following information:

(*a*) Diameter of pulley; (*b*) width of belt (width of belt is necessary in order that proper allowance may be made in the sleeve length for bearing surface); (*c*) diameter of shaft; (*d*) solid or split (use split only when absolutely necessary); (*c*) revolutions of shaft per minute; (*f*) horsepower required at starting and thereafter; (*g*) character of service; (*h*) if for gas engine service, state number of cylinders; (*i*) if space on shaft is limited, give maximum allowable space; (*j*) key sizes.



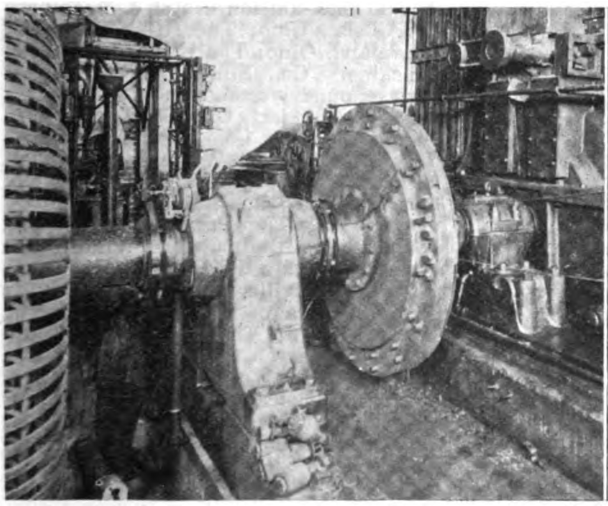
This diagram names the parts of a clutch.

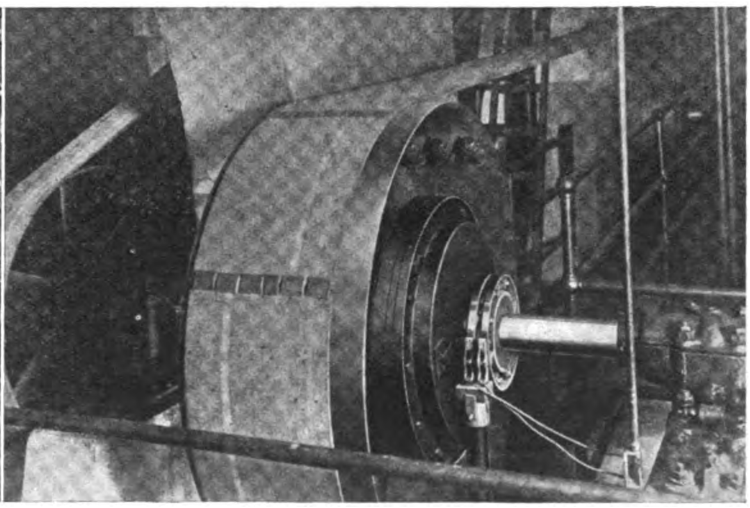
In ordering a repair part or extra parts for replacement the manufacturer must know the type, style, or model, size, any special dimensions, and if possible the original order number.

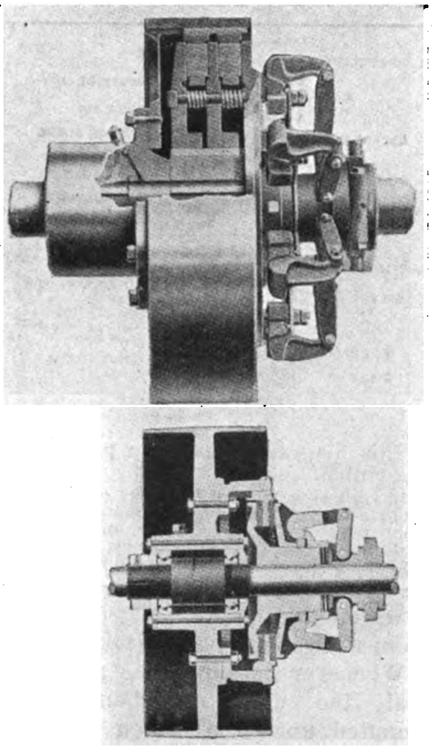
Whenever possible it is advisable that the clutch mechanism be mounted upon the driven shaft in order that adjustments may be made without shutting down the entire line. Ordinarily, ¼ in., or on a large shaft a little more, should be allowed between the ends of the two shafts with cutoff couplings. In some types the end of one shaft extends into the hub of the other. When erecting friction clutches or couplings one of the first steps is to see that the shaft is properly aligned and round and smooth where the sleeve runs. The coupling or clutch should be thoroughly cleaned out and the bore of the sleeve and the shaft lubricated before slipping the sleeve into position. Next see that the sleeve is a free running fit on the shaft, as not all shafts are of exact standard gage. Before ordering the coupling, measure to see if the shaft is off gage; if so have the coupling bored to gage. Before the

Magnetic cutoff coupling and clutch pulley installations.

The installation below shows a 30-in. magnetic clutch fastened to a pulley on an engine-driven, paper-making machine. The engine and clutch are installed in the basement of the paper mill and the paper machine on the first floor. The operator starts and stops the paper machine by means of a switch located conveniently. The installation at the left shows a magnetic cutoff clutch coupling connecting a synchronous motor to a mill.







Two disk-type friction clutch couplings.

In one of these clutches, the disengagement is through the aid of the toggles while in the other a spring assists in forcing the jaws apart.

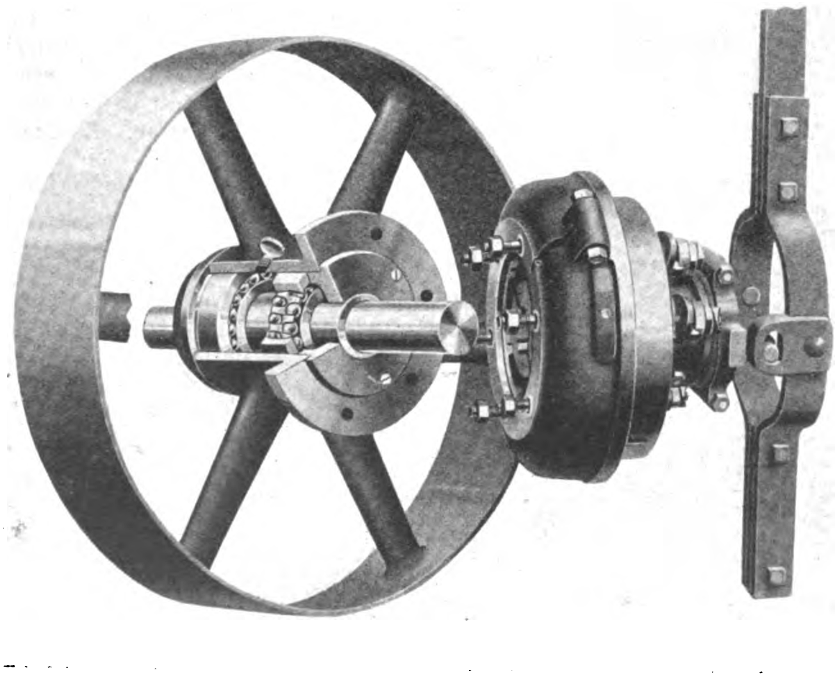
clutch is operated it must be thoroughly lubricated by forcing in as much lubricant as possible. In some cases it may be necessary to fill the grease cups two or three times before all spaces and passages are filled. The most important step after the clutch is in service is to see that it is regularly and thoroughly lubricated. Clutches used frequently should receive daily attention unless they are of the ball-bearing type.

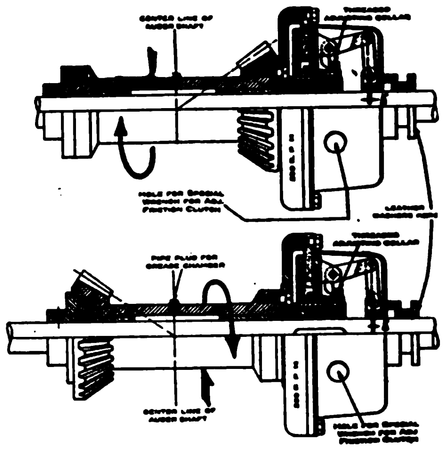
After a friction clutch or coupling has been in operation it is sometimes necessary to make slight adjustments to compensate for the wear of the friction surfaces. In doing this care should be exercised to see that the different arms of the clutch are tightened evenly or else they will be thrown out of adjustment and not give even pressure, or they rub at some point when disconnected. With some types of clutches all adjustments are made at once, so that all are made evenly. A friction surface will wear rapidly if permitted to rub while disengaged. If the jaws rub on the friction surface, either the springs do not force the jaws apart sufficiently or else the clutch is not properly adjusted.

One of the important considerations in installing friction clutch cut-off couplings is to see that the shafting is properly in line before installing the coupling. It is always well to remember that even though properly aligned when first installed, shafting does not always remain that way. Shifting loads or machines on floors above often may change the alignment of a shafting. Frequent inspections of shafting for alignment not only reduce the friction load but also more than pay for

Cut-away view of a ball-bearing friction clutch pulley.

One of the common causes of difficulty with loose pulleys and clutch pulleys lies in the liability to neglect the lubrication. For high-speed work as well as clutches and pulleys which are difficult of access, and so are liable to be neglected, ball bearings are recommended because of the less frequent necessity of lubrication.





One method of getting the proper direction of rotation.

In many machines, it is absolutely necessary that the shafts revolve in a certain direction. In this pair of clutches, the spur gear is reversed, as shown in the two sketches. This is a single-disk friction clutch, where the pressure is applied equally on both sides of the disk.

themselves in the savings on bearings, friction clutches, and other similar equipment. Two of the more common causes of excessive wear in friction clutches and couplings are misalignment of shafting and neglect of lubrication. If the shaft is aligned properly, and the coupling lubricated and of sufficient capacity there should be but little opportunity for trouble.

EDITOR'S NOTE: Special acknowledgment is made to the following companies for their assistance in furnishing information and illustrations for this and the other articles which appear in this series: Allis-Chalmers Mfg. Co., Milwaukee, Wis.; The Bartlett Hayward Co., Baltimore, Md.; Charles Bond Co., Philadelphia, Pa.; Bond Foundry & Machine Co., Manheim, Pa.; Brown Engineering Co., Reading, Pa.; The Carlyle Johnson Machine Co., Manchester, Conn.; Chicago Pulley & Shafting Co., Chicago, Ill.; Conway & Co., Cincinnati, Ohio; The Cutler-Hammer Mfg. Co., Milwaukee, Wis.; I. H. Dexter Co., Goshen, N. Y.; Dodge Manufacturing Co., Mishawaka, Ind.; Falls Clutch & Machinery Co., Cuyahoga Falls, Ohio; The Falk Corporation, Milwaukee, Wis.; General Electric Co., Schenectady, N. Y.; The Hanson Clutch & Machinery Co., Tiffin, Ohio; The Hill Clutch Co., Cleveland, Ohio; The Hilliard Clutch & Machinery Co., Elmira, N. Y.; W. A. Jones Foundry & Machine Co., Chicago, Ill.; The Medart Co., St. Louis, Mo.; Mesta Machine Co., West Homestead, Pa.; The Moore & White Co., Philadelphia, Pa.; The F. V. Edwards Co., Noblesville, Ind.; R. D. Nuttall Co., Pittsburgh, Pa.; The Pusey & Jones Co., Wilmington, Del.; Reeves Pulley Co., Columbus, Ind.; R. H. & F. M. Roots Co., Connersville, Ind.; A. L. Schultz & Son, Chicago, Ill.; Smith & Serrel, Newark, N. J.; Thomas Flexible Coupling Co., Warren, Pa.; Weller Mfg. Co., Chicago, Ill.; Western Engineering & Mfg. Co., Chicago, Ill.; The Williams Foundry & Machine Co., Akron, Ohio; T. B. Wood's Sons Co., Chambersburg, Pa.

INASMUCH AS alternating current motors can be reconnected for different voltages by taking advantage of various series and parallel connections, and of star and delta arrangements in three-phase designs, it is important to know which connections are best suited to the stator construction and operating conditions. When rewinding a stator there are even more combinations that can be used by varying the number of turns per coil and the coil pitch. In this article Mr. Roe presents handy tables which show the changes that can be made.

Some Handy Tables For Use in Making

Voltage Changes on A. C. Motors

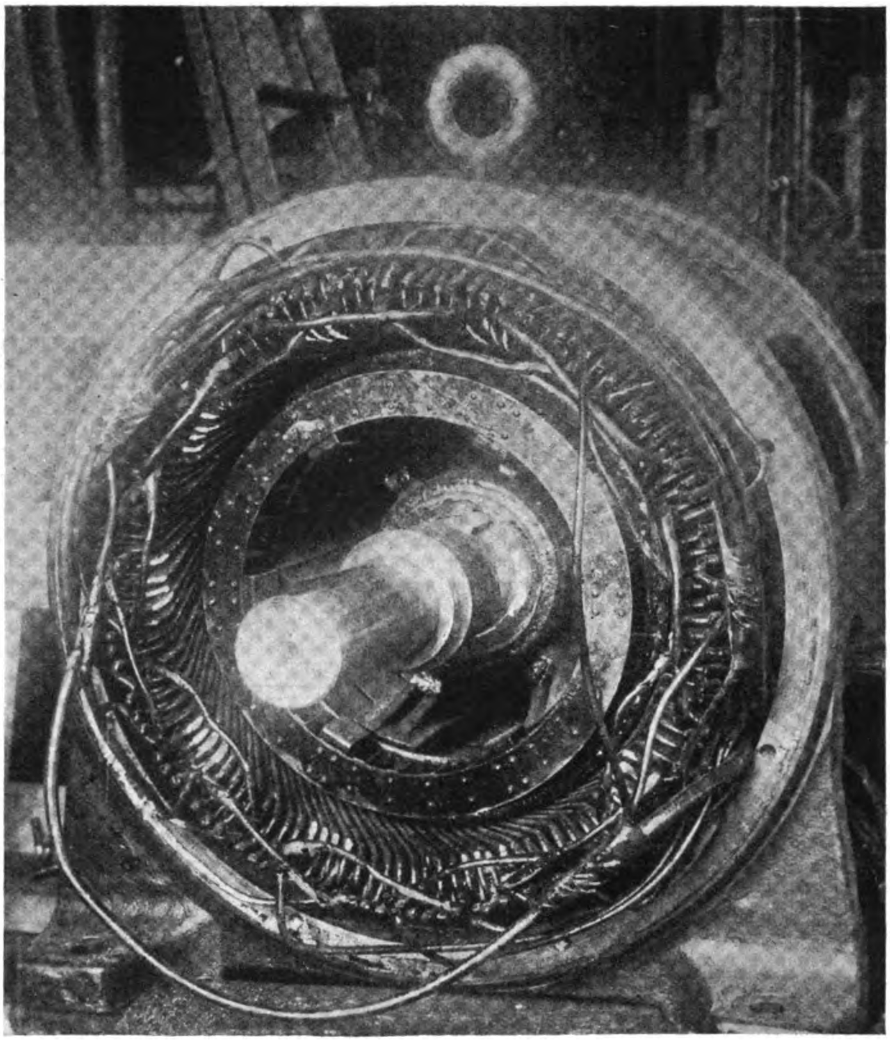
By Reconnecting, or by Changing Coil Pitch and Chord Factor and by Rewinding the Coils

By A. C. ROE
Repair Superintendent, Detroit Service Department, Westinghouse Electric & Manufacturing Co.

QUITE often it is desired to reconnect the windings of an induction motor to operate on different line voltages or, when rewinding a stator, some bad feature in the coils or connections may be eliminated by changing the type of connections, the coil pitch, the turns per coil, and so on. It is the purpose of this article, therefore, to discuss the various changes that affect the voltage and to outline the possibilities of removing bad features as well as the effects of over- and undervoltage on the operation of the motor.

To begin with, we can consider the stator winding of an induction motor as a generator. Then any change made that tends to increase or decrease the turns in series per phase will also increase or decrease the voltage in the same proportion and in the same direction as that in which the turns are changed. In applying this rule in practice we must remember, also, that when the turns per phase are changed more than 10 per cent, a corresponding change in the cross section of the conductor should be made in the same proportion, but in the opposite direction.

One important rule when rewinding or reconnecting a motor is to keep the voltage per turn the same as it was originally, if the horsepower, speed, frequency and number of phases are to remain the same. Also be sure that the new arrangement of the winding is within 5 per cent of the proper line voltage, if possible, and in any case do not exceed 10 per cent either way. These figures can sometimes be exceeded for intermittent duty and temporary jobs and will no doubt work satisfactorily, but for a good permanent job, keep within these limits. This can usually be done by changing the type of connection, the turns per coil and the chord factor. Sometimes, however, it is not possible to keep the voltage the same. In such a case the effect of undervoltage or overvoltage must be considered.



After examining the existing connections the next step is to decide whether the stator should be reconnected or rewound.

The most common voltage changes are from 220 volts to 110 volts, 220 to 440, 440 to 110, or *vice versa* in each case. On some stators this can be accomplished by reconnecting from series to two-parallel, etc., depending upon the number of poles, coils per phase and the original connection. When the original connection is a series connection, it is obvious that the voltage can not be increased by reconnecting. In this case it is necessary to rewind the stator with the turns per coil increased in the same proportion as the voltage is to be increased. At the same time the size of wire (circ. mil) must be decreased in the same proportion.

Do not attempt to raise the voltage of 110-, 220-, 440-, and 550-volt motors above 550 volts without rewinding, as the insulation to ground and between phases on motors of this voltage range is not sufficient to stand continuous operation at higher voltage. It may be possible to jug-

gle the connections to get the desired voltage but this should not be done.

Another point to remember when making a voltage change is: Do not attempt to parallel the coils in any one pole-phase-group. This means that on first sight it might seem that we cannot split a group in half and parallel the halves with each other. Each group could be split into two sections of two coils and these two sections put in parallel. However, if this were done circulating currents would be set up, due to angular displacement of the different pairs of coils. If the motor were connected in this manner and put on the line, in about ten minutes it would be found that there were two hot coils, then two cool coils, alternately, throughout the winding. Therefore, when reconnecting do not split the groups but use them as units.

To help determine what connection to use to get the required volt-

Table I—All Practical Connections for 4-to 24-Pole, 2-Phase Windings

The first vertical column gives the original connection. Each figure on the same horizontal line with any original connection is the multiple to be used to find the line voltage for the connection listed at the top of the different columns. For example, assume that a 440-volt, two-phase, four-pole, series-connected, motor is to be reconnected two-parallel and it is desired to know the resulting operating voltage. On consulting the table for a four-pole, two-phase winding, look in the first column and find the line in which the word "series" is located. Then in the column marked "two-parallel" (2-Par.) the figure .5 is found which, multiplied by 440 volts (440 × .5) equals 220 volts, which is the operating voltage when the winding is changed to two-parallel.

As another case, assume that it is desired to change the same motor to operate on 110 volts. What connection would give the desired result? In this case divide 110 by 440 (110 ÷ 440) which gives .25. Then look along the horizontal line under original connection column marked "series" of the table for four-pole, two-phase motors and locate the figure .25 which will be found under four-parallel (4-Par.) connection. This indicates that the four-parallel connection will give the required operating voltage of 110, since 440 × .25 equals 110.

Four-Pole, Two Phase

Original Connection	Series	2-Par	4-Par.
Series	1.00	.50	.25
2-Parallel	2.00	1.00	.50
4-Parallel	4.00	2.00	1.00

Six-Pole, Two-Phase

Original Connection	Series	2-Par.	3-Par.	6-Par.
Series	1.00	.50	.333	.167
2-Parallel	2.00	1.00	.667	.334
3-Parallel	3.00	1.50	1.00	.500
6-Parallel	6.00	3.00	2.00	1.000

Eight-Pole, Two-Phase

Original Connection	Series	2-Par.	4-Par.	8-Par.
Series	1.00	.50	.25	.125
2-Parallel	2.00	1.00	.50	.250
4-Parallel	4.00	2.00	1.00	.50
8-Parallel	8.00	4.00	2.00	1.00

Ten-Pole, Two-Phase

Original Connection	Series	2-Par.	5-Par.	10-Par.
Series	1.00	.50	.20	.1
2-Parallel	2.00	1.00	.40	.2
5-Parallel	5.00	2.50	1.00	.5
10-Parallel	10.00	5.00	2.00	1.0

Twelve-Pole, Two-Phase

Original Connection	Series	2-Par.	3-Par.	4-Par.	6-Par	12-Par.
Series	1.00	.500	.33	.25	.167	.083
2-Parallel	2.00	1.00	.667	.50	33	.167
3-Parallel	3.00	1.50	1.00	.75	.50	.25
4-Parallel	4.00	2.00	1.33	1.00	.66	.334
6-Parallel	6.00	3.00	2.00	1.50	1.00	.50
12-Parallel	12.00	6.00	4.00	3.00	2.00	1.00

Fourteen-Pole, Two-Phase

Original Connection	Series	2-Par.	7-Par.	14-Par.
Series	1.00	.50	.143	.071
2-Parallel	2.00	1.00	.286	.143
7-Parallel	7.00	3.50	1.00	.50
14-Parallel	14.00	7.00	2.00	1.00

Sixteen-Pole, Two-Phase

Original Connection	Series	2-Par.	4-Par.	8-Par.	16-Par.
Series	1.00	.50	.25	.125	.0625
2-Parallel	2.00	1.00	.50	.25	.125
4-Parallel	4.00	2.00	1.00	.50	.25
8-Parallel	8.00	4.00	2.00	1.00	.50
16-Parallel	16.00	8.00	4.00	2.00	1.00

Eighteen-Pole, Two-Phase

Original Connection	Series	2-Par.	3-Par.	6-Par.	9-Par.	18-Par.
Series	1.00	.50	.33	.167	.11	.056
2-Parallel	2.00	1.00	.66	33	.22	.11
3-Parallel	3.00	1.50	1.00	.50	.33	.167
6-Parallel	6.00	3.00	2.00	1.00	.66	.33
9-Parallel	9.00	4.50	3.00	1.50	1.00	.50
18-Parallel	18.00	9.00	6.00	3.00	2.00	1.00

Twenty-Pole, Two-Phase

Original Connection	Series	2-Par.	4-Par.	5-Par.	10-Par.	20-Par.
Series	1.00	.50	.25	.20	.10	.05
2-Parallel	2.00	1.00	.50	.40	.20	.10
4-Parallel	4.00	2.00	1.00	.80	.40	.20
5-Parallel	5.00	2.50	1.25	1.00	.50	.25
10-Parallel	10.00	5.00	2.50	2.00	1.00	.50
20-Parallel	20.00	10.00	5.00	4.00	2.00	1.00

Twenty-two-Pole, Two-Phase

Original Connection	Series	2-Par	11-Par.	22-Par.
Series	1.00	.50	.091	.046
2-Parallel	2.00	1.00	.182	.091
11-Parallel	11.00	5.50	1.00	.500
22-Parallel	22.00	11.00	2.00	1.000

Twenty-four-Pole, Two-Phase

Original Connection	Series	2-Par.	3-Par.	4-Par.	6-Par.	8-Par.	12-Par.	24-Par.
Series	1.00	.50	.33	.25	.165	.125	.083	.0415
2-Parallel	2.00	1.00	.66	.50	.33	.25	.167	.083
3-Parallel	3.00	1.50	1.00	.75	.50	.375	.25	.125
4-Parallel	4.00	2.00	1.33	1.00	.66	.50	.33	.165
6-Parallel	6.00	3.00	2.00	1.50	1.00	.75	.50	.25
8-Parallel	8.00	4.00	2.66	2.00	1.33	1.00	.66	.33
12-Parallel	12.00	6.00	4.00	3.00	2.00	1.50	1.00	.50
24-Parallel	24.00	12.00	8.00	6.00	4.00	3.00	2.00	1.00

age or what the line voltage should be with any other possible connection, Tables I to VII have been developed. There are two tables for each number of poles, one for two-phase and one for three-phase. Each table gives all the possible connections for each of the number of poles to which it applies. The first vertical column in a table gives the original connection; then each figure on the same horizontal line with any original connection is the multiple to be used to find what the line voltage should be with the connection listed in the top line. Assume a 440-volt, two-phase, four-pole motor series connected. On consulting Table I we look in the first column and find the horizontal line in which the word *Series* is located. Then the first figure is 1 and above this figure is the word *Series* which indicates that no change is made. But the second figure is .5 which indicates that with two-parallel connection the motor would have to operate with $440 \times .5$ equals 220 volts. Again under *4-Parallel* appears the figure .25. This signifies that with a four-parallel connection the line voltage would have to be $440 \times .25$ equals 110 volts. Another use of the table is to find the required connection for a certain voltage. Assuming the same motor as before, a 440-volt series connection, suppose it is desired to change the voltage to 110. What connection would give the desired results? To find the factor divide the required voltage by the original voltage, or $110 \div 440 = .25$. In doing this be sure about the position of the decimal point. Then looking along the original connection (series) horizontal line we locate .25 under *4-Parallel* which connection will give the required voltage.

For three-phase stators the tables are found more useful, as there are two types of connection possible: namely, star and delta. This gives a greater range of combinations. In any star-connected machine the voltage per phase is equal to line voltage divided by 1.73. In other words if a series, star-connected motor is operating on a 220-volt three-phase line, the volts per phase will be 127. This motor could be connected series-delta and operated on 127 volts which is approximately 58 per cent of the series-star line voltage. Conversely, a 110-volt, series-delta-connected motor could be connected series-star and operated on 1.73×110 equals 190 volts. A few actual examples will be given to show the use of the tables.

Suppose we have a three-phase, six-pole 2,300-volt motor that is connected two-parallel star (2-Par. Y) and we want to reconnect it for 440 volts. Then $440 \div 2{,}300$ equals .1913. Consulting Table II and the *2-Parallel Star* horizontal line, we find the factor .193 under *6-Parallel Delta*. Then if we connect the motor six-parallel delta it would require a line voltage of $2{,}300 \times .193$ or 443.9 volts, which is 3.9 volts over but is satisfactory.

In another case assume that we have a 110-volt, three-phase, twelve-pole motor, six-parallel connected and want to reconnect it for 550 volts. Then the factor required is $550 \div 110$ equals 5.0. Looking in Table III on the *6-Parallel Delta* line, we find the factor 5.2 under *2-Parallel Star*. If, we, accordingly, reconnect this motor for two-parallel star, the line voltage will have to be 110×5.2 equals 572 volts, or 22 volts over 550, which is satisfactory, as standard motors are listed to operate on 10 per cent over- or under-voltage. Another example is a 24-pole, three-phase, 4,600-volt, series-star-connected motor which it is desired to reconnect for 110 volts. Then $110 \div 4{,}600$ equals .024.

Table II—All Practical Connections for 2-to 8-Pole, 3-Phase Windings

See heading of Table I for instructions on using these tables.

Two-Pole, Three-Phase

Original Connection	Series Star	Series Delta	2-Par. Star	2-Par. Delta
Series—Star	1.00	.58	.50	.29
Series—Delta	1.73	1.00	.865	.50
2-Parallel—Star	2.00	1.16	1.00	.58
2-Parallel—Delta	3.46	2.00	1.73	1.00

Four-Pole, Three-Phase

Original Connection	Series		2-Parallel		4-Parallel	
	Star	Delta	Star	Delta	Star	Delta
Series—Star	1.00	.58	.50	.29	.25	.145
Series—Delta	1.73	1.00	.865	.50	.432	.25
2-Parallel—Star	2.00	1.16	1.00	.58	.50	.29
2-Parallel—Delta	3.46	2.00	1.73	1.00	.865	.50
4-Parallel—Star	4.00	2.32	2.00	1.16	1.00	.58
4-Parallel—Delta	6.92	4.00	3.46	2.00	1.73	1.00

Six-Pole, Three-Phase

Original Connection	Series		2-Parallel		3-Parallel		6-Parallel	
	Star	Delta	Star	Delta	Star	Delta	Star	Delta
Series—Star	1.00	.58	.500	.29	.333	.193	.167	.096
Series—Delta	1.73	1.00	.865	.50	.576	.333	.289	.167
2-Parallel—Star	2.00	1.16	1.00	.58	.666	.386	.334	.193
2-Parallel Delta	3.46	2.00	1.73	1.00	1.152	.666	.578	.334
3-Parallel—Star	3.00	1.73	1.50	.865	1.00	.577	.500	.288
3-Parallel Delta	5.19	3.00	2.60	1.50	1.73	1.000	.865	.500
6-Parallel Star	6.00	3.46	3.00	1.73	2.00	1.15	1.00	.577
6-Parallel Delta	10.38	6.00	5.19	3.00	3.46	2.00	1.73	1.000

Eight-Pole, Three-Phase

Original Connection	Series		2-Parallel		4-Parallel		8-Parallel	
	Star	Delta	Star	Delta	Star	Delta	Star	Delta
Series—Star	1.00	.58	.50	.29	.25	.145	.125	.0725
Series—Delta	1.73	1.00	.865	.50	.432	.25	.216	.125
2-Parallel—Star	2.00	1.16	1.00	.58	.50	.29	.25	.145
2-Parallel—Delta	3.46	2.00	1.73	1.00	.865	.50	.432	.25
4-Parallel—Star	4.00	2.32	2.00	1.16	1.00	.58	.50	.29
4-Parallel—Delta	6.92	4.00	3.46	2.00	1.73	1.00	.865	.50
8-Parallel—Star	8.00	4.64	4.00	2.32	2.00	1.16	1.00	.58
8-Parallel Delta	13.84	8.00	6.92	4.00	3.46	2.00	1.73	1.00

It can be seen that the tables will be of considerable help in solving many reconnection problems. The connecting diagrams published in the March, April, May and June issues of INDUSTRIAL ENGINEER can be used with these tables.

To illustrate how changing the type of connection can be done in some cases to speed up a rewinding job, it may be well to mention a recent case which came under the writer's supervision. We had a 96-slot, three-phase stator connected two-parallel star. This was to be rewound to perform the same duties as before. There were ninety-six coils, diamond-pulled, of fourteen turns of one No. 13 square wire. The wires in the coil were laid two wide by seven deep which is called a "cross-over" coil. Each cross-over had to be taped which meant that each coil would require considerable time to make. But it was found that this cross-over could be eliminated by using a plain coil and changing the motor connections. Accordingly the coils were made up of seven turns of two No. 13 square wires in parallel (2 by 7) thus cutting the turns per coil in half and eliminating the cross-over. This type of coil can be wound in one-third the time required for a cross-over coil. Changing the turns to one-half also increased the cross section of copper 100 per cent and this would indicate that the motor should be operated on half the original voltage. However, the connections were changed from two-parallel star to series-star enabling the motor to run on original voltage.

It is combined changes like this one that enable a great deal of time to be saved in repair work. Furthermore, the time saved is not the only benefit derived from eliminating a cross-over coil. Another important feature is that with the average help in most repair shops there is more chance for short circuits in cross-over coils. The reason for this is illustrated in Fig. 1. At

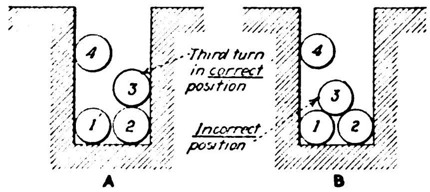


Fig. 1—How short circuits in cross-over coils frequently occur.

At *A* is shown the first three turns wound correctly in place. The first turn is at the left, the second on the right and the third is on top of the second. At this point trouble starts, as the third turn has a tendency to slip down into the space formed on top of the two round wires, as shown in diagram *B*. When the fourth turn is laid in and an attempt made to flatten out the second layer by pounding with a drift and mallet, there is not enough space between the third turn and the side of the shuttle for the fourth turn. This pounding tends to crush the cotton covering on wires 3 and 4 and may cause a dead short circuit.

A are shown the first three turns wound correctly in place. The first turn is at the left, the second on the right, and the third is on top of the second. It is at this point that trouble starts, as the third turn has a tendency to slip down into the space formed on top of the two round wires, as in drawing *B*. When the fourth turn is laid in and an attempt made to flatten out the second layer by pounding with a fiber drift and mallet, there is not enough space between the third turn and the side of the shuttle for the fourth turn.

Pounding tends to crush the cotton covering on wires 3 and 4. If they are pounded hard enough the insulation will be cut and a dead short will result. Unless each coil is carefully inspected, this defect will not be noticed until the stator is wound and given a balance and run test which means time lost in removing the faulty coils.

There is another item that can be changed to vary the voltage when rewinding. This is the chord factor, which may be changed by changing the coil pitch. The chord factor depends entirely on the pitch, the number of poles, and it will be the same for any number of phases.

The chord factor is equal to the sin of one-half the electrical angle included between the two halves of one coil. In practice the chord factor is found as follows: First divide

Table III—All Practical Connections for 10-and 12-Pole, 3-Phase Windings

See heading of Table I for instructions on using these tables

Ten-Pole, Three-Phase

Original Connection	Series		2-Parallel		5-Parallel		10-Parallel	
	Star	Delta	Star	Delta	Star	Delta	Star	Delta
Series—Star	1.00	.58	.50	.29	.20	.116	.10	.058
Series—Delta	1.73	1.00	.865	.50	.346	.20	.173	.10
2-Parallel—Star	2.00	1.16	1.00	.58	.40	.232	.20	.116
2-Parallel—Delta	3.46	2.00	1.73	1.00	.692	.40	.346	.20
5-Parallel—Star	5.00	2.90	2.50	1.45	1.00	.58	.50	.29
5-Parallel—Delta	8.65	5.00	4.32	2.50	1.73	1.00	.865	.50
10-Parallel—Star	10.00	5.80	5.00	2.90	2.00	1.16	1.00	.58
10-Parallel—Delta	17.30	10.00	8.65	5.00	3.46	2.00	1.73	1.00

Twelve-Pole, Three-Phase

Original Connection	Series		2-Parallel		3-Parallel		4-Parallel		6-Parallel		12-Parallel	
	Star	Delta	Star	Delta	Star	Delta	Star	Delta	Star	Delta	Star	Delta
Series—Star	1.00	.58	.50	.29	.33	.193	.25	.145	.167	.096	.084	.048
Series—Delta	1.73	1.00	.865	.50	.576	.333	.432	.25	.288	.167	.144	.084
2-Parallel—Star	2.00	1.16	1.00	.58	.66	.386	.50	.29	.334	.193	.167	.097
2-Parallel—Delta	3.46	2.00	1.73	1.00	1.15	.66	.865	.50	.578	.334	.288	.167
3-Parallel—Star	3.00	1.73	1.50	.87	1.00	.58	.75	.435	.50	.29	.25	.145
3-Parallel—Delta	5.19	3.00	2.60	1.50	1.73	1.00	1.30	.75	.865	.50	.432	.25
4-Parallel—Star	4.00	2.32	2.00	1.16	1.33	.772	1.00	.58	.66	.386	.33	.193
4-Parallel—Delta	6.92	4.00	3.46	2.00	2.30	1.33	1.73	1.00	1.15	.66	.577	.33
6-Parallel—Star	6.00	3.46	3.00	1.73	2.00	1.16	1.50	.87	1.00	.58	.50	.29
6-Parallel—Delta	10.38	6.00	5.19	3.00	3.46	2.00	2.60	1.50	1.73	1.00	.865	.50
12-Parallel—Star	12.00	6.92	6.00	3.46	4.00	2.30	3.00	1.73	2.00	1.15	1.00	.57
12-Parallel—Delta	20.76	12.00	10.38	6.00	6.92	4.00	5.19	3.00	3.46	2.00	1.73	1.00

the total number of *slots (N)* by the number of poles *(P)*. This gives the number of slots per pole. Then take the coil pitch *(C)* and divide it by the number of slots per pole. This will give the pitch as a fraction of full pitch. Multiply 90 deg. by this fraction and the result will be a certain number of degrees. Then the sin of this angle equals the chord factor. These steps may be reduced to one formula which is:

Chord factor = sin C ÷ N/P × 90 degrees.

(Note: First divide *N* by *P*. Then divide *C* by this answer and multiply by 90.)

In this formula: N = Total number of slots; P = Number of poles; C = Coil pitch.

The sin may be found from Table VIII in this article or from other tables in handbooks.

For example, assume a 96-slot, four-pole stator, with coil pitch of 1-and-20, or 19 slots. The chord factor equals sin $[19 \div (96 \div 4)] \times 90 = (19 \div 24) \times 90 = .79125 \times 90 =$ sin 71.21 deg. In many tables the fraction of a degree is expressed in *minutes* and consequently the .21 of the 71.21 must be reduced to minutes. There are 60 min. per 1 deg.; therefore $60 \times .21 = 12$ min.

The sin of this angle 71.21 deg. (or 70° 12′) equals .9466, which equals the chord factor. If the voltage of the motor with full pitch was 100 volts, it would be 94.66 volts with the above-mentioned pitch of 1-and-20 (19 slots).

Suppose that in the example given above it was found that eighteen

Table IV—All Practical Connections for 14-to 20-Pole, 3 Phase Windings

See heading of Table I for instructions on using these tables

Fourteen-Pole, Three-Phase

Original Connection	Series		2-Parallel		7-Parallel		14-Parallel	
	Star	Delta	Star	Delta	Star	Delta	Star	Delta
Series—Star	1 00	.58	.50	.29	.143	.083	.071	.042
Series—Delta	1.73	1.00	.865	.50	.247	.143	.124	.071
2-Parallel—Star	2.00	1.16	1.00	.58	.286	.166	.143	.083
2-Parallel—Delta	3.46	2.00	1.73	1.00	.494	.286	.247	.143
7-Parallel—Star	7.00	4.06	3.50	2.03	1.00	.58	.50	.29
7-Parallel—Delta	12.11	7.00	6.06	3.50	1.73	1.00	.865	.50
14-Parallel—Star	14.00	8.12	7.00	4.06	2.00	1.16	1.00	.58
14-Parallel—Delta	24.22	14.00	12.11	7.00	3.46	2.00	1.73	1.00

Sixteen-Pole, Three-Phase

Original Connection	Series		2-Parallel		4-Parallel		8-Parallel		16-Parallel	
	Star	Delta	Star	Delta	Star	Delta	Star	Delta	Star	Delta
Series—Star	1.00	.58	.50	.29	.25	.145	.125	.073	.063	.037
Series—Delta	1.73	1.00	.865	.50	.432	.25	.216	.125	.108	.063
2-Parallel—Star	2.00	1.16	1.00	.58	.50	.29	.25	.145	.125	.073
2-Parallel—Delta	3.46	2.00	1.73	1.00	.865	.50	.432	.25	.216	.125
4-Parallel—Star	4.00	2.32	2.00	1.16	1.00	.58	.50	.29	.25	.145
4-Parallel—Delta	6.92	4.00	3.46	2.00	1.73	1.00	.865	.50	.432	.25
8-Parallel—Star	8.00	4.64	4.00	2.32	2.00	1.16	1.00	.58	.50	.29
8-Parallel—Delta	13.84	8.00	6.92	4.00	3.46	2.00	1.73	1.00	.865	.50
16-Parallel—Star	16.00	9.28	8.00	4.64	4.00	2.32	2.00	1.16	1.00	.58
16-Parallel—Delta	27.68	16.00	13.84	8.00	6.92	4.00	3.46	2.00	1.73	1.00

Eighteen-Pole, Three-Phase

Original Connection	Series		2-Parallel		3-Parallel		6-Parallel		9-Parallel		18-Parallel	
	Star	Delta	Star	Delta	Star	Delta	Star	Delta	Star	Delta	Star	Delta
Series—Star	1.00	.58	.50	.29	.33	.193	.167	.097	.11	.064	.055	.032
Series—Delta	1.73	1.00	.865	.50	.577	.33	.289	.167	.19	.11	.09	.055
2-Parallel—Star	2.00	1.16	1.00	.58	.66	.386	.33	.193	.22	.128	.11	.064
2-Parallel—Delta	3.46	2.00	1.73	1.00	1.15	.66	.577	.33	.38	.22	.18	.11
3-Parallel—Star	3.00	1.73	1.50	.86	1.00	.58	.50	.29	.33	.193	.167	.097
3-Parallel—Delta	5.19	3.00	2.59	1.50	1.73	1.00	.865	.50	.57	.33	.28	.167
6-Parallel—Star	6.00	3.46	3.00	1.73	2.00	1.15	1.00	.58	.66	.383	.33	.191
6-Parallel—Delta	10.38	6.00	5.19	3.00	3.46	2.00	1.73	1.00	1.15	.66	.57	.33
9-Parallel—Star	9.00	5.19	4.5	2.59	3.00	1.73	1.50	.87	1.00	.57	.50	.285
9-Parallel—Delta	15.57	9.00	7.78	4.50	5.19	3.00	2.59	1.50	1.73	1.00	.86	.50
18-Parallel—Star	18.00	10.38	9.00	5.19	6.00	3.46	3.00	1.73	2.00	1.15	1.00	.575
18-Parallel—Delta	31.14	18.00	15.57	9.00	10.38	6.00	5.19	3.00	3.46	2.00	1.73	1.00

Twenty-Pole, Three-Phase

Original Connection	Series		2-Parallel		4-Parallel		5-Parallel		10-Parallel		20-Parallel	
	Star	Delta	Star	Delta	Star	Delta	Star	Delta	Star	Delta	Star	Delta
Series—Star	1.00	.58	.50	.29	.25	.145	.20	.116	.10	.058	.05	.029
Series—Delta	1.73	1.00	.865	.50	.432	.25	.346	.20	.173	1.00	.087	.05
2-Parallel—Star	2.00	1.16	.10	.58	.50	.29	.40	.232	.20	.116	.10	.058
2-Parallel—Delta	3.46	2.00	1.73	1.00	.865	.50	.692	.40	.346	.20	.173	.10
4-Parallel—Star	4.00	2.32	2.00	1.16	1.00	.58	.80	.464	.40	.232	.20	.116
4-Parallel—Delta	6.92	4.00	3.46	2.00	1.73	1.00	1.38	.80	.69	.40	.345	.20
5-Parallel—Star	5.00	2.90	2.50	1.45	1.25	.725	1.00	.58	.50	.29	.25	.145
5-Parallel—Delta	8.65	5.00	4.32	2.50	2.16	1.25	1.73	1.00	.865	.50	.432	.25
10-Parallel—Star	10.00	5.80	5.00	2.90	2.50	1.45	2.00	1.16	1.00	.58	.50	.29
10-Parallel—Delta	17.30	10.00	8.65	5.00	4.32	2.50	3.46	2.00	1.73	1.00	.865	.50
20-Parallel—Star	20.00	11.60	10.00	5.80	5.00	2.90	4.00	2.32	2.00	1.16	1.00	.58
20-Parallel—Delta	34.60	20.00	17.30	10.00	8.65	5.00	6.92	4.00	3.46	2.00	1.73	1.00

turns per coil would be correct for a line voltage of 440 with a full pitch coil, 1 and 25. However, the coil ends with this pitch projected out beyond the iron too far and interfered with the end bells and to wind properly the coil had to be shortened to a pitch of 1 and 20. Now shortening the coil pitch decreases the activity of the coil sides and the coil will develop less voltage. This is easily understood because we know that with full pitch both halves of the coil are in maximum fields at the same instant, hence the coil is developing its maximum voltage; but when the pitch is shortened, one side of the coil will be in a weaker field and the coil will develop a lower voltage. So changing the coil pitch has practically the same effect on the voltage as changing the turns per coil; decreasing the coil pitch decreases the voltage and *vice versa.* The amount of change is indicated by the chord factor. In the above case the chord factor is .9466 for coil pitch 1 and 20; then the line voltage would be 440 × .9466, equals 416.40 volts. To bring the voltage back to 440, the turns would have to be increased 5.6 per cent, or 18 × 1.056, equals 19.006 turns. In this case dropping five slots has the same effect as dropping one turn per coil.

A much simpler tabulation of chord factors is shown in Table V. In this table the first column gives the pitch in the percentage of full pitch. The second column gives the chord factor corresponding to this percentage of pitch. As an example of using this table suppose we have a six-pole, 120-slot stator with a pitch of 1 and 19 or 18 slots. Full pitch equals 120 ÷ 6 equals 20 slots. The present pitch is 18 ÷ 20 or 90 per cent of full pitch. From the table we find that for 90 per cent pitch the chord factor is 0.988.

Table V—Chord Factors for Different Coil Pitches

Per Cent Pitch	Chord Factor	Per Cent Pitch	Chord Factor
100	1.00000	75	.92388
99	.99988	74	.91775
98	.99951	73	.91140
97	.99889	72	.90483
96	.99803	71	.89803
95	.99692	70	.89101
94	.99556	69	.88376
93	.99396	68	.87631
92	.99211	67	.86863
91	.99002	66	.86074
90	.98769	65	.85264
89	.98511	64	.84433
88	.98229	63	.83581
87	.97922	62	.82708
86	.97592	61	.81815
85	.97237	60	.80902
84	.96858	59	.79968
83	.96456	58	.79015
82	.96029	57	.78043
81	.95579	56	.77051
80	.95106	55	.76041
79	.94608	54	.75011
78	.94088	53	.73963
77	.93544	52	.72917
76	.92978	51	.71813

Many a time when rewinding a stator the coils are accidentally made up a bit short, thus making a tight winding job. Another time the end room on the original winding may have been scant, so that if the same pitch is used when rewinding the job will again be difficult.

In either case dropping one or two slots may ease things up and make a quicker and safer job, but the question is, how will this affect the machine? As already stated, reducing the voltage of a generator while operating on the original line voltage will reduce its overload capacity, and in a motor will cause the motor to operate on overvoltage, the effects of which will be more fully explained later in this article. In general, the effect of dropping one slot will be less in a machine with a large number of slots and a small number of poles. In any machine if the effect is not greater than 7 per cent no harm will result from reducing the pitch, except in cases where the machine is already being pushed to or beyond its rated capacity. In this case any change that tends to reduce the capacity should be avoided.

Another case in which a better job resulted from decreasing the pitch came up recently. This was a stator in which the winding was

Table VI—All Practical Connections for 22- and 24-Pole, 3-Phase Windings

See heading of Table I for instructions on using these tables.

Twenty-two-Pole, Three-Phase

Original Connection	Series		2-Parallel		11-Parallel		22-Parallel	
	Star	Delta	Star	Delta	Star	Delta	Star	Delta
Series—Star	1.00	.58	.50	.29	.091	.053	.045	.026
Series—Delta	1.73	1.00	.865	.50	.157	.091	.078	.045
2-Parallel—Star	2.00	1.16	1.00	.58	.182	.105	.091	.053
2-Parallel—Delta	3.46	2.00	1.73	1.00	.314	.182	.157	.091
11-Parallel—Star	11.00	6.38	5.50	3.19	1.00	.580	.50	.290
11-Parallel—Delta	19.03	11.00	9.52	5.50	1.73	1.00	.865	.50
22-Parallel—Star	22.00	12.76	11.00	6.38	2.00	1.16	1.00	.58
22-Parallel—Delta	38.06	22.00	19.03	11.00	3.46	2.00	1.73	1.00

Twenty-four-Pole, Three Phase

Original Connection	Series		2-Parallel		3-Parallel		4-Parallel		6-Parallel		8-Parallel		12-Parallel		24-Parallel	
	Star	Delta	Star	Delta	Star	Delta	Star	Delta	Star	Delta	Star	Delta	Star	Delta	Star	Delta
Series—Star	1.00	.58	.50	.29	.333	.193	.25	.145	.165	.097	.125	.073	.083	.048	.041	.024
Series-Delta	1.73	1.00	.865	.50	.577	.33	.432	.25	.29	.165	.216	.125	.145	.083	.073	.041
2-Parallel—Star	2.00	1.16	1.00	.58	.66	.386	.50	.29	.33	.193	.25	.145	.167	.096	.083	.048
2-Parallel—Delta	3.46	2.00	1.73	1.00	1.15	.66	.865	.50	.577	.33	.432	.25	.29	.167	.145	.083
3-Parallel—Star	3.00	1.74	1.50	.87	1.00	.58	.75	.435	.50	.29	.375	.217	.25	.144	.125	.073
3-Parallel—Delta	5.19	3.00	2.59	1.50	1.73	1.00	1.29	.75	.865	.50	.648	.375	.432	.25	.216	.125
4-Parallel—Star	4.00	2.32	2.00	1.16	1.33	.77	1.00	.58	.66	.385	.50	.29	.33	.193	.165	.097
4-Parallel—Delta	6.92	4.00	3.46	2.00	2.30	1.33	1.73	1.00	1.15	.66	.865	.50	.577	.33	.29	.165
6-Parallel—Star	6.00	3.48	3.00	1.74	2.00	1.16	1.50	.87	1.00	.58	.75	.435	.50	.288	.25	.145
6-Parallel—Delta	10.38	6.00	5.19	3.00	3.46	2.00	2.59	1.50	1.73	1.00	1.29	.75	.865	.50	.432	.25
8-Parallel—Star	8.00	4.64	4.00	2.32	2.66	1.54	2.00	1.16	1.33	.77	1.00	.58	.66	.386	.33	.193
8-Parallel—Delta	13.84	8.00	6.92	4.00	4.60	2.66	3.46	2.00	2.30	1.33	1.73	1.00	1.16	.66	.585	.33
12-Parallel—Star	12.00	6.96	6.00	3.48	4.00	2.32	3.00	1.74	2.00	1.16	1.50	.87	1.00	.58	.50	.29
12-Parallel—Delta	20.76	12.00	10.38	6.00	6.92	4.00	5.19	3.00	3.46	2.00	2.59	1.50	1.73	1.00	.865	.50
24-Parallel—Star	24.00	13.92	12.00	6.96	8.00	4.64	6.00	3.48	4.00	2.32	3.00	1.74	2.00	1.16	1.00	.58
24-Parallel—Delta	41.52	24.00	20.76	12.00	13.84	8.00	10.38	6.00	6.92	4.00	5.19	3.00	3.46	2.00	1.73	1.00

Table VII—Possible Number of Connections for 2-to 24-Pole Windings

No. of Poss. Conn.	No. of Poles	Series	2-Par.	3-Par.	4-Par.	5-Par.	6-Par.	7-Par.	8-Par.	9-Par.	10-Par.	11-Par.	12-Par.	13-Par.	14-Par.	16-Par.	18-Par.	20-Par.	22-Par.	24-Par.
2	2	X	X																	
3	4	X	X		X															
4	6	X	X	X			X													
4	8	X	X		X				X											
4	10	X	X			X					X									
6	12	X	X	X	X		X						X							
4	14	X	X					X							X					
5	16	X	X		X				X							X				
6	18	X	X	X			X			X							X			
6	20	X	X		X	X					X							X		
4	22	X	X									X							X	
8	24	X	X	X	X		X		X				X							X

tight. This was a 120-slot, eight-pole, 220-volt stator with a pitch of 1 and 13 or 80 per cent pitch. The winding had pulled and insulated diamond-shaped coils. Before pulling the new set of coils it was decided to try the 1 and 12 pitch which would increase the winding angle and make a better job. The 1 and 13 chord factor is $[12 \div (120 \div 8)] \times 90 = 12/15 \times 90$ or 72 degrees. The sin of 72 deg. $= 0.951$. The chord factor of the 1-and-12 pitch is sin $[11 \div (120/8)] \times 90 = 11/15 \times 90 = 65.97$ or sin 66 degrees, which is 0.913. Then by using the 1-and-12 pitch the voltage would be reduced to $220 \times (0.913 \div 0.951) = 220 \div .96 = 211.2$ volts. This is a reduction of $220 - 211.2 = 8.8$ volts. In percentage this is $(8.8 \div 220) \times 100$ or 4 per cent and the motor will operate satisfactorily with this reduction, as a 7 per cent change is allowable. Now if this stator had 180 slots and was a six-pole machine with 80 per cent pitch, which equals 24 slots or 1 and 25, and the pitch was dropped to 1 and 24, the reduction in voltage would be less. From Table V the chord factor for the 80 per cent pitch is 0.951. The 1 and 24 chord factor (76.7 per cent pitch) is 0.93. The new line voltage is $220 \times (.934 \div .951)$ equals 216 volts. This is $(220\text{-}216) \div 220 \times 100$ equals 1.8 per cent reduction. Comparing this with the reduction of 4 per cent in the previous case proves the statement that the greater the number of slots and the less the number of poles, the smaller will be the effect of one slot dropped.

Another case in which time was saved by eliminating a cross-over coil occurred on a recent rush and overtime rewinding job. The motor had a 120-slot stator, rated 20 hp., 440 volts, three-phase, 60 cycles, ten-pole, 675 r.p.m., connected series-delta, pitch 1 and 9, coils with ten turns of one No. 11 round d.c.c. wire wound 2×5 cross-over, diamond shape, and connected in a two-layer, threaded-in winding. To save time the winding was checked to see if the cross-over could be eliminated.

There were 120 coils or forty per phase and 40×10 equals 400 turns per phase. Then with a series-delta connection the volts per turn is $440 \div 400$ equals 1.1. Now using a five-turn coil of two No. 11 wires in parallel in a series-star connection the voltage would be $5 \times 1.1 \times 40 \times 1.73$ equals 380.6 which is 16 per cent under the required voltage. This, however, was raised by increasing the pitch and chord factor. The original pitch was 1 and 9 which gives a chord factor of 0.866. Full pitch would, of course, give 100 per cent chord factor. Then with the full pitch (1 and 13) five-turn coil and series-star connection the line voltage would be $380.6 \div .866 = 439.4$ volts, which is close enough. Checking the end room it was found sufficient to take the longer coil.

With over-voltage the magnetizing current will vary as the square of the voltage, if the iron is working below the saturation point. This current should be expressed as a percentage of the total current. The iron losses will be increased approximately 1.8 times the per cent voltage increase. This value holds only for increases of voltage of 10 or 15 per cent.

The copper losses will be lower, due to the fact that with a higher voltage a smaller current will be required for the same hp. rating.

The slip (or the difference, expressed as a percentage, between the no-load and full-load r.p.m.) will vary inversely as the square of the voltage or:

$S_1 \div S_2 = V_1^2 \div V_2^2$, wherein S_1 equals the per cent slip at rated voltage, V_1, and S_2 is the per cent slip at the higher or new voltage, V_2. The power factor will be slightly lower at the increased voltage. The maximum or pull-out and starting torques are increased in proportion to the square of the voltage. The decrease in copper losses more than offsets the increased iron losses.

For 10 to 15 per cent voltage difference from standard, the friction and windage can be assumed to be the same, as these two depend upon a variation in speed and the percent of change in speed is too small to affect these factors to any extent.

If the motor were not loaded to its maximum rating the effects of over-voltage would be more noticeable. The lighter the load the greater the iron loss will be in proportion to the copper losses. Also, the decrease in power factor at light loads is more evident as the magnetizing current is increased. With a 15 per cent voltage increase and one-half load, the motor is quite likely to run hot enough to burn out. But on the other hand if the motor were overloaded and the voltage increased, the motor would run cooler, as the torque increases as the square of the voltage and the speed remains the same. Hence with an increase in torque the hp. rating would be increased with a lower current consumption. *(Continued on page 158)*

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Chicago, March, 1924

Penny Wise and Pound Foolish

INASMUCH as mechanical and electrical superintendents are held strictly responsible for production delays, they should have the same control of specifications and requisitioning of equipment and supplies as they do over the maintenance and inspection of equipment. The following incident shows what serious consequences may result when the plant maintenance organization does not specify the equipment and supplies that are to be used:

During a regular overhauling period the oil was drained from one of the motor bearings of a 3,000-hp. flywheel motor-generator set which supplied power to the main drive motor of a reversing blooming mill. The oil cellar was cleaned and refilled to the proper level with new oil. The next morning the motor-generator was started and the customary inspection was made to see that the oil rings were running freely and carrying up oil. A couple of hours later it was noticed that the bearing in which the oil had been changed, was heating. Preventive measures were taken but before they became effective, the babbitt melted and the shaft dropped. Fortunately, the motor was stopped before any damage was done to the rotor or stator windings.

After considerable trouble, the motor shaft was jacked up, the pedestal removed and the bearing taken out. Inspection disclosed no dirt or other foreign matter on the shaft or in the oil. Examination of the oil, however, revealed that it was of a somewhat lighter grade than was formerly used. A new bearing was put in the motor and the original grade and make of oil was again used. The bearing caused no further trouble.

From an investigation of the source of the oil it was found that a somewhat lower price was offered the purchasing department and that department substituted an oil made by another manufacturer, but claimed to be of the same grade as the original oil. The plant maintenance organization was not informed of this change and when a workman was sent to the storeroom after oil for this machine, the substituted oil was given him. The initial saving on the price of the oil was less than $4.00 a barrel. The direct loss caused by the substitution of the oil was a damaged bearing, the time and trouble of replacing it, and a half day's delay of the mill. The cost of a new bearing and of installing it was in the neighborhood of $100.00. The production delay was serious, as the blooming mill was the bottle neck of the plant. Furthermore, if the hot bearing had not been discovered in time, several thousand dollars' worth of damage might have been done to the motor winding.

The initial cost may be a little higher when the plant organization specifies material to be bought, but the operating expense per unit of finished product will be far lower in practically every case.

Where Some Profits Lie Hidden

EVERY business must show a profit or it cannot continue long to operate. When it ceases operating, all jobs and wages stop with it. Well-managed concerns expect to make a certain profit on each dollar's worth of business. Ordinarily this may be increased either by getting more business or by unanticipated economies. Those who ignore as of little consequence the miscellaneous savings in materials or methods which cannot be visualized in physical shapes, but take the form of a decrease in time out of productive machinery through better attention, inspection and maintenance, need only consider the relative return resulting from handling more business or from economies in handling its existing volume. To realize an economy of $1,000 a year, and many savings will total this much, would require an increase in business done of $20,000, assuming the profit to be 5 per cent on each dollar's worth of this business.

Men responsible for inspection and maintenance have a big opportunity to assist in making these miscellaneous economies, particularly in plants where suggestion boxes or other methods are used to get the ideas of the men on possible betterments of methods or equipment. The work of these men takes them over the plant where they learn first-hand of the troubles of the machine operators on the various jobs. Their training leads them to look for the source of the trouble, which is often some distance from the point where it shows up, and offer a solution or at least make a suggestion. Companies which have successful suggestion box methods have found the men in the maintenance department one of the best sources of worth-while ideas.

Men with ideas, particularly those which help make profit, are the ones who get ahead.

Don't Let Notions Take the Place of Facts

A POWER transmission engineer recently called our attention to an instance where he was asked to recommend a drive for a machine driven by a silent chain with which an unusual amount of trouble had been experienced. When he went to the plant to make an investigation the manager refused to let him see the machine in question, with the explanation that he could give the engineer all of the necessary information. When the latter refused to give his services under such conditions, permission was at last granted to make an inspection.

This engineer found that the chain drive in question was the most important drive in the plant and was rated at 350 hp., but pulling a load which he knew by previous experience amounted to nearly 500 hp. The manager absolutely refused to have a test made to determine the power demand on the drive. He "knew" it was not over 350 hp.—and that settled it. As the only way out of the situation the engineer sent in an order for a 350-hp. chain, and instructed the factory to ship a 500-hp. chain. That particular chain has now been in operation for some time and has given no trouble whatever.

Whether the engineer should have resorted to this trick need not be discussed here. There is no question, however, of the absurdity of the manager's attitude. His refusal to seek and use facts instead of beliefs cost his company many thousands of dollars and this loss would probably have continued if he had had his way.

Although this is an extreme example, it is typical of similar experiences which this engineer and probably many others have had with executives who clung very tenaciously to their hazy or erroneous notions of the size or type of equipment required for a particular service.

Pre-conceived notions may sometimes serve a useful purpose, but when they do not square up with the facts they should promptly be discarded. You can fool yourself as to the power requirements of a drive, but you can't fool the motor or other elements of the drive—and it does not pay to try it.

The Peg on Which Blame Is Hung

DURING the last hour of the turn when all hands are striving to get out the few extra tons of steel to make the day's quota, a vital machine, such as the shear approach table, stops. The electrical department is called immediately and all hands assume the attitude that someone there is the cause of the delay. Now why is the electrical department the peg on which the blame for such faults is hung?

The reasoning is usually something like this: The machine has stopped. The motor is intended to run it. Since the motor doesn't move, it must be an electrical trouble and, therefore, the chief electrician has to get busy. He will probably say that in the majority of his calls the trouble has not been with his end of the machine. However, he inspects his part of the equipment until he feels sure that it is all right. But he cannot prove his case until the wheels are turning again and he usually has to hunt until he locates the mechanical fault that caused the delay. He will tell you that in a great many cases he finds that the bearings of the drive have become so worn as to cause the gears to bind; or the oiler has not oiled the bearings at the regular time—hence the shafts are gripping; or some bolts holding the roller shaft bearings came loose, causing a misalignment which made the table bind; or any of the other mechanical faults that creep in.

Mechanical trouble is something that can be seen from its very inception. Careful and regular mechanical inspection while the machine is in operation will disclose a loose bearing, a misalignment of gears or shafts, hot bearings and the like, before the fault becomes dangerous. Steps for temporarily correcting it until it can be repaired can usually be taken so as to continue production. Electrical faults are more difficult to locate and do not always make themselves evident until the damage is done.

The chief electrician has a hard job at best—don't assume that he alone should have to locate mechanical troubles to clear his own skirts. The master mechanic and his millwright are also a part of the maintenance force and they too can and will help when their part in the work carries recognition as well as some blame for the things that happen.

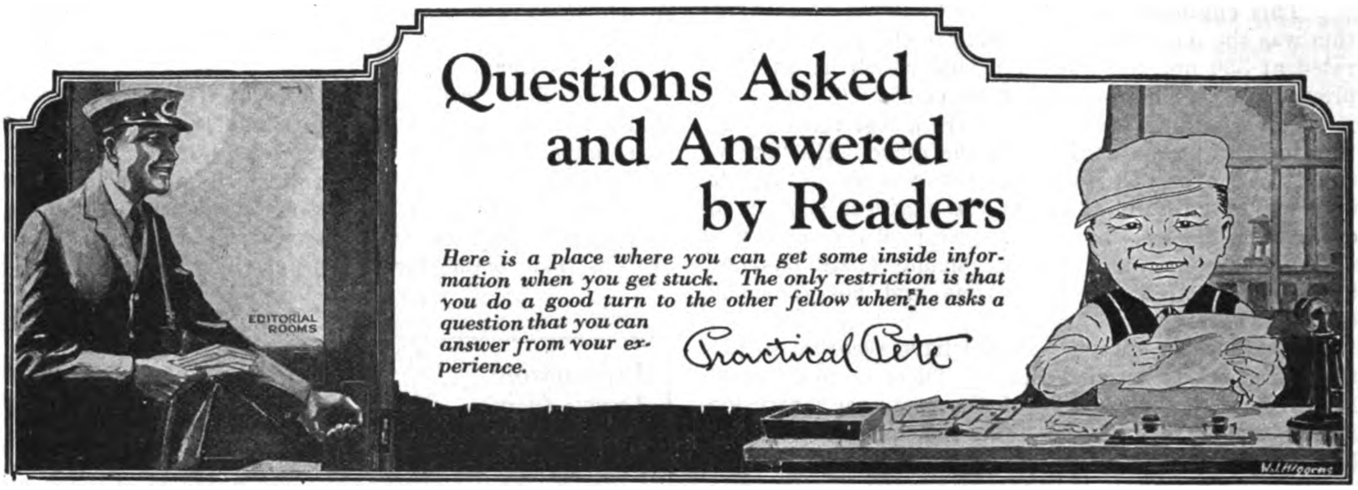
Preventable Losses from Break-Downs

IN A RECENT address before the Society of Industrial Engineers, Guy H. Rumpf, Works Manager of Joseph T. Ryerson & Sons, Inc., made a very practical analysis of the factors that control production in an industrial works. The four essentials of a production unit he set down as: (1) Plant, (2) Material, (3) Men and (4) Management. In regard to the plant he made the following comment:

> There are few ideal plants, due to the fact that these plants have grown, having been built up from time to time as the particular business increased. These additions were probably not made with ultimate planning in view and as a result, unless a growing business decided to rebuild their plant, the layouts are not always the best that could be desired. * * * It never pays to buy poor equipment and many times it can be proved that it will be cheaper to scrap certain equipment and buy new equipment. In order to prove this, however, it is necessary to determine the saving which can be made with new equipment, taking into consideration the interest on the investment and the depreciation of the particular machine that may be purchased.
>
> In this connection, all equipment needs to be taken care of and repaired. If it is not kept up, it will soon deteriorate and wear out long before it should. It is a good plan to inspect all equipment at regularly determined intervals and repair it in accordance with the needs indicated by such inspection, rather than allow equipment to run until it breaks down and then repair it out of necessity.
>
> In the first case, repairs do not cost as much and you can choose the time when you wish to make them. In the second, repairs will always cost more and the machine is sure to break down when you need it the most.

In most plants that have been operating for, say ten years, the greatest increase in profits at the end of any year will not come from the increase in work turned out but the attention paid to avoidable wastes in handling a normal volume of work with breakdowns reduced to a minimum, machines running at normal capacity continuously and little loss of time due to transporting materials to and from machines so that as the material flows through the plant the time it is worked on between raw state and finished form is the highest possible percentage of the total time each part is traveling through processes of production. Breakdowns and interruptions are one of the factors which make losses from non-productive time hard to estimate. Inspections and repairs must be considered as a regular routine on a day-to-day basis and an essential part of any production schedule.

The economy advocated by the Chinese doctor is possible here. He gets pay for his services while the patient is well, but he prevents the loss of earnings through inability to work. This Chinese doctor idea is overlooked in many plants and consequently they pay for the repairs and the loss of productive time as well, when the latter might be saved by a little regular prevention here and there.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Conventional Diagram of Four-Pole, Three-Phase Motor—Can some reader give me the conventional diagram, as in Dudley's book, together with the method of connection, of a four-pole, three-phase motor, wound on the 120-deg. principle, such as is found in certain Wagner motors?

Portland, Oregon. V. G. W.

* * * *

Installing Signal Lamp on Single-Phase Electric Furnace—Can any of our readers tell me how to install a signal lamp on a single-phase electric furnace?

There is a switch on the primary side of the transformer that furnishes current for the furnace, and I wish to find some way of installing a light between the top carbon electrode and the bottom contact, so that when the switch is released by a short circuit from a piece of metal falling against the carbon electrode, we can tell by this light whether the electrode has been raised high enough to break contact with the metal, before throwing in the switch.

The winding in the transformer forms a permanent circuit, so that we cannot apply any outside source of current to operate this light. It would save us considerable money if we were able to connect up a light of this kind, as the cost of carbon electrodes and contacts for the switch runs into considerable money. I shall appreciate very much any suggestions which you can give me.

Michigan City, Ind. P. V. H.

* * * *

Changing 25-Cycle Motor to Operate on 60 Cycles—I have a General Electric repulsion-induction, single-phase motor which has the following nameplate data: No. 3124538, type RI 546-2-1-1500, form C, 25 cycles, full load speed 1,495 r.p.m., volts 220, amp. 5, volts 110, amp. 10, 1 hp. continuously, 50 deg. C. Some of the part numbers are: pulley end bearing lining, cat. 329792; stator coil spec. 205425; rotor spec. 3005030.

The rotor dimensions are 5 in. (diam.) x 3⅛ in. It has twenty-three slots, 1⅛ in. deep, and sixty-nine bars. The stator has thirty-two slots. I thought this was a standard 2-hp., 60-cycle RI frame but find that this is not the case. I should like to know: (1) If the above motor is any standard 60-cycle RI frame. (2) Complete data for rewinding this motor for 110-220 volts, 60 cycles, 1,800 r.p.m., single phase. (3) What will be the rating of the motor after rewinding?

Portland, Ore. V. G. W.

* * * *

What Causes This Motor to Spark at the Brushes?—I have a 35-hp., four-pole, shunt-wound motor that drives a fan. The armature has seventy coils, lap-wound. Under load this machine draws 280 amp. at 115 volts and has always sparked viciously. The brushes are of the Bayliss type and I find the neutral point with a voltmeter as closely as one can. When I stone the commutator down the motor runs satisfactorily for a day or so and then sparking begins and the commutator develops low bars and seems to flatten or sink.

I am wondering if this armature was designed for a four-pole machine, as it has seventy bars and coils. This number is not divisible by four without a remainder and thus throws the neutral point in the center of a bar. I shall be very grateful if some reader can explain what causes the sparking and tell me how I can overcome it.

New York, N. Y. C. E. K.

* * * *

Winding Data for Retor of Repulsion-Induction Motor—Can someone tell me the correct way to wind the rotor of a single-phase, repulsion-induction motor which has four poles and four brushes? The motor appears to be about 1 hp. The nameplate is missing, but the motor has thirty-four slots and seventy-six bars. The coils have four turns, wound two in hand, using No. 13 d.c.c. wire. The coil pitch is 1 and 9. Nine pairs of the bars were shorted, I believe in the order X, 7X, 6X, 7X, 6X, 7X, 6X, 7X, 6X, 6, the X representing a shorted pair of bars. I have tried six or seven common pitches without success, the motor locking at certain points in each case. Is it impossible to start up with this commutator?

Lewistown, Pa. G. R. F.

* * * *

Winding Data for Washing Machine Motor—Can some reader supply me with the winding data for a Westinghouse washing machine motor? According to the nameplate this is a 60-cycle, 1,700 r.p.m., motor, 220-110 volts, 2-4 amp. The laminations are 6¼ in. in diameter; the inside bore is 3½ in. and the axial length of the core is 2⅝ in. There are twenty-four slots, ¾ in. deep and ⅝ in. wide. The teeth are ⅛ in. wide at the top and ¼ in. wide at the base. This motor employes a starting winding. I shall appreciate any information which you can give me. S. McP.

Hercules, Calif.

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Rewinding Westinghouse Fan Motor—I wish to rewind a Westinghouse Whirlwind fan motor, style No. 280598, to operate on 110 volts, 60 cycles, alternating current. Can some of the readers of INDUSTRIAL ENGINEER tell me the proper size of wire to use and how many turns should be put in each coil. Apparently this motor had only two coils? Is this correct?

Marietta, Ohio. E. L.

* * * *

Winding Data for Type KT-4 General Electric Motor—Will some of the readers of INDUSTRIAL ENGINEER kindly tell me the proper winding for a type KT-4, form C, General Electric motor, No. 678120, 3 hp., 1,800 r.p.m., 220 volts, 60 cycles? What size wire should be used and how should the coils be connected? I wish to have this motor operate on 50 cycles. Should any change be made in the original winding?

Pasadena, Calif. H. B. S.

* * * *

Operating 60-Cycle Repulsion Motor on 25 Cycles—I have a ½-hp., 110-volt, 60-cycle, single-phase repulsion motor with a new winding in the rotor. The only current available here is 110 volts, 25 cycles. I wanted to test this motor out and when I connected it to the line it would start nicely, but as soon as the mechanical switch cut out the rotor would stop instantly, as nearly as I could see. Then just as soon as the brushes got back on the commutator the rotor would immediately start and then stop again, and so on.

The coil pitch and commutator connections are the same as in the old winding. I have checked up the winding for shorts and polarity and it appears to be all right. I should like to know, (1), if this motor will run satisfactorily on 60 cycles. (2) What makes the motor start and stop this way on 25 cycles? I shall appreciate any suggestions which readers of INDUSTRIAL ENGINEER can give me.

Massena, N. Y. F. A.

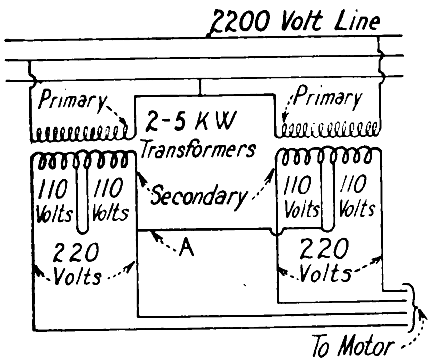
Answers Received To Questions Asked

Putting Tires on Wheels of Bandsaws—Will someone be kind enough to tell me what is the best method of putting tires on the wheels of bandsaws? I shall appreciate this information very much.
Chicago, Ill. J. W. C.

J. W. C. asked in the January issue for the best method of putting tires on wheels of bandsaws. I retired two machines recently and he may be interested in learning how I did it. First, I removed the old tires from the wheels and sandpapered the latter until all of the old rubber and cement was removed. Then I applied a liberal coat of cement made for this purpose and stretched the new tires on over the wheels. I allowed the cement to dry over night before using the bandsaw. If a special, prepared cement is not furnished with new tires, a coat of heavy varnish may be used instead of this, with very satisfactory results. E. L. WAY.
Marietta, Ohio.

* * * *

Trouble in Operating Two-phase Arc Welder Set on Three-phase Circuit—I had occasion recently to operate a two-phase, four-wire, 220-volt, 60-cycle, 1,800 r.p.m., 5-hp. Lincoln motor, which is direct connected to a Lincoln welding generator, on a three-phase, 2,200-volt, 60-cycle circuit. The transformer connection shown was tried. I found that the motor would start but in a short time would get very hot. The wire at *A* was cut and then the motor did not heat so much, so that by stopping the

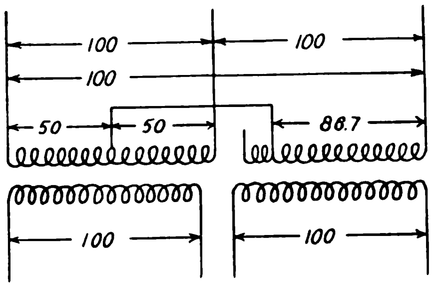


machine about every hour and letting it cool off I was able to do the welding, but too much time was lost. I wish some of the readers of INDUSTRIAL ENGINEER would tell me if this connection is correct and if so, what causes the motor to heat.
Tyrone, Pa. H. L. F.

In answer to the question asked by H. L. F. in the December issue, of INDUSTRIAL ENGINEER, I believe that his motor would have operated more satisfactorily if he had left out the line marked *A*. As a solution of his problem I would suggest that he use the General Electric Co.'s type MTQ transformer or employ the T connection with two single-phase transformers. EARLE N. DILLARD.
Chief Electrician,
Booth-Kelley Co.,
Springfield, Ore.

* * * *

In reply to the question by H. L. F. in the December issue, I would say that it would be impossible to obtain two-phase current with the connection which he used. The motor was being supplied with two phases having a phase angle of 120 deg. instead of 90 deg. as required. This condition would greatly reduce the torque for a given current and cause the motor to over-heat at its rated output. I do not believe that the wire *A* in his diagram would have any effect on the heating of a four-wire, two-phase motor.



Scott connection of transformers for changing three-phase to two-phase, or the reverse.

The correct connection for obtaining two-phase current from a three-phase circuit is shown in the diagram. As will be seen, the Scott connection is used on the three-phase side. Transformers for this purpose are on the market.
LYLE HENDRICKS.
District Electrician,
Pickands Mather Company,
Hibbing, Minn.

* * * *

In reply to the question asked by H. L. F. in the December issue, beyond any doubt the trouble is in the transformer connections employed in changing from three-phase to two-phase. The scheme of connections shown would result in a severe unbalancing of the two phases. H. L. F. should use what is known as the Scott connection. For this purpose one transformer should have a 50 per cent tap on the primary and the other transformer should be tapped at a point 86.6 per cent from one end. In actual practice, a 10 per cent tap would be enough, unless the transformers are to be paralleled with another bank using different connections.
Chief Engineer, PHILIP N. EMIGH.
Mountain Water Supply Co.,
Indian Creek, Pa.

In answer to the question by H.L.F. in the December issue, from the diagram of transformer connections shown it is evident that an unbalanced voltage condition causes the motor on the welder to heat. If the ratio of one of the transformers is changed from 10 to 1 to 8.6 or 9 to 1, better results will be obtained. The standard method of three-phase to two-phase transformation is by means of the Scott connection, which can be found in all handbooks. The diagram shown by H.L.F. shows the unbalanced T connection.
General Electric Co., L. B. MORRILL.
Boston, Mass.

* * * *

Trouble with Portable Electric Drill—I have been having trouble with a Westinghouse, ⅜-in., portable drill. This drill operated satisfactorily for two years and then began running at only half speed. Occasionally it would start off on normal speed, but soon drop back to half speed. I rewound the stator and when this did not clear the trouble I rewound the armature, with no better results. Instead of winding the armature on a form I wound it by hand. So far, I have not been able to get it to run at normal speed.

Another portable drill, a Van Dorn, came in recently with the armature roasted. I wound this armature by hand and it, too, ran at half speed. I rewound the armature again, this time on a form but so far have not been able to get it up to full speed although the field coils have been tested out and seem to be all right. The armature core number of the Westinghouse drill is 12-A-876; the Van Dorn armature coil number is Code 8406. Both drills are designed to operate on 110-volt alternating current. I shall appreciate it very much if some reader can tell me what is the matter with these drills.
Philadelphia, Pa. R. I. G.

With reference to the question asked by R. I. G. in the December issue of INDUSTRIAL ENGINEER, we do not make any drills, but in checking up the stock order, 12-A-876 which R. I. G. states was stamped on the armature, we find that this order number covers a 110-volt motor which we supplied to the U. S. Electrical Tool Co. of Cincinnati, Ohio, for their type CU ⅜-in. drill. For this application we supplied our type AD universal motor, which has the compensating type of field winding. It is our supposition that when R. I. G. rewound the stator he became confused and wound both fields the same; that is, he connected the main and compensating windings in such a manner that he made a four-pole motor instead of a two-pole motor. This would account for the motor operating between half speed and full-load speed, although it

would not run at exactly half speed with the two brush outfit.

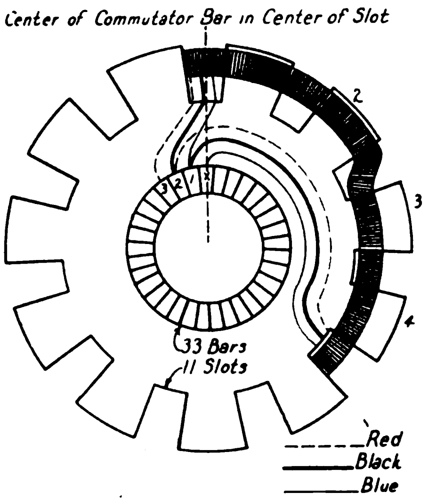
It is also possible that the armature is short circuited, which would also help to slow down the speed. I would suggest that the motor be sent to our nearest service station, in this case Philadelphia, to be rewound. A. M. STAEHLE.

Westinghouse Elec. & Mfg. Co.,
East Pittsburgh, Pa.

* * * *

Answering R. I. G., whose question appeared in the December issue, my experience would seem to indicate that the portable drills mentioned have one or more short circuits in the armature. The usual tests for these should be made.

The Van Dorn 110-volt armature, code 8406, is wound with No. 26 d. s. c. wire. Since there are three times as many commutator segments as armature slots it should be wound with three wires in hand. Each coil



Commutator connection diagram for armature of Van Dorn portable electric drill.

consists of fifteen turns around four teeth. The commutator should be assembled with the center line of the segments opposite the center line of the slots. The diagram shows how the commutator should be connected.

Electrical Engineer, E. L. CONNELL.
The Van Dorn Electric Tool Co.,

* * * *

Method of Soldering Leads to Commutator Bars—Can any of the readers of INDUSTRIAL ENGINEER give me the following information: (1) The design of a transformer for soldering the leads to the commutator risers with the aid of carbon electrodes. (2) I have done armature winding on large machines, but would like to know the best way of soldering leads to commutators of fractional-horsepower motors, such as fans. I should like to know the type of soldering iron to use, and other information that will help me to save time.
San Francisco, Calif. S. H. S.

In the December issue S. H. S. asked for information on the best methods of soldering commutator leads. On small armatures we use a medium-size iron and apply it to the brush surface of the commutator, instead of the necks. By using an iron of the proper size, the whole commutator is heated and with plenty of solder and flux you can make a quick and thorough soldering job. The commutator is covered with solder—in fact it looks like a lead commutator, but this is all taken off when the commutator is turned. No extra cut or time is required, as the commutator always has to be turned after a rewinding job. A. C. ROE.

Detroit, Michigan.

* * * *

What Causes this Magnet Switch to Stick?—We have on a crane hoist a 440-volt a.c. magnetic limit switch which fails to open about one-half of the time when the current is taken off the magnet coil. Although the core is laminated, there is apparently enough magnetism left to hold the switch in. All of the working parts are clean and free. Will someone kindly suggest a remedy for this trouble?
Selby, Calif. J. T. C.

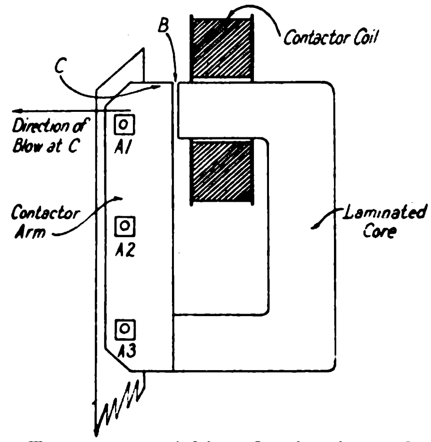
In answer to the question by J.T.C. in the December issue of INDUSTRIAL ENGINEER, without knowing the exact type of magnetic switch in question it is impossible to determine the trouble definitely but generally when a switch fails to drop when the current is taken off the holding coil, it is due to improper adjustment at the solenoid. Of course, when there is no current in the coil the solenoid should drop by gravity as the permanent magnet is not strong enough to hold the armature up. There is generally an adjusting screw and locknut to adjust the space between the core and armature. If not, a weight may be hung on the armature which will be heavy enough to make it drop and yet not too heavy to allow the armature to pull in when the coil is energized.

Of course, there is always a possibility of a short in the control connections which will allow at least part of the current to pass through the coil when it is apparently dead.

General Electric Co., L. B. MORRILL.
Boston, Mass.

* * * *

Referring to J. T. C's question in the December issue of INDUSTRIAL ENGINEER, I had about the same experience on the control of a large hoist. After carefully examining the switch I found the laminated core was so battered that instead of an air space at *B*, as shown in the illustration, the contactor arm hit flush with both ends of the core. By loosening nuts A_1, A_2 and A_3 and pounding the laminations of the arm at point *C*, I was able to move the laminations enough to allow a small air space between the contactor arm and the laminated core. After tightening the nuts the switch was put



To prevent sticking, laminations of contactor arm were pounded back to allow small air space, *B*, between arm and laminated core.

back in service and worked satisfactorily until new parts were received.

I hope this information will be of some assistance to J. T. C.

Goldfield, Nev. PHIL D. COMER.

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Replying to the question by J. T. C. in the December issue, the core and armature of an a.c. magnet are laminated not so much to prevent sticking from the residual magnetism as to prevent eddy currents which would overheat an a. c. magnet of any size. In addition, an a. c. magnet would take considerably more exciting current if it were made of solid iron, like a d. c. magnet. If magnetism is holding your magnet closed while the current is off, the trouble is in the air gap which has probably been reduced or eliminated by wear. If the magnet works freely when operated by hand, it should also work freely when operated electrically, provided that it has an air gap of 0.005 in. or over in the magnetic circuit. This air gap is always found on the leg nearest the hinge of the magnet and if this gap is less than 0.005 in., or the thickness of two or three sheets of writing paper when the magnet is closed and excited it should be increased by filing that leg or the part of the armature with which it lines up. The hinge should, of course, be examined first and the

wear taken up, if wear is the cause of the trouble. The further or outer leg of the magnet must not be filed as a carefully ground or scraped fit is very important, as well as a proper shading ring or coil if quiet operation is to be expected.

PHILIP G. BERNHOLZ.
East Orange, N. J.

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Operating Two-Phase Induction Motor on Three-Phase Circuit—I should like to know if a two-phase induction type or squirrel-cage motor can be run on a three-phase circuit, keeping the same speed and pulling the same load. I should like very much to have someone give me a diagram of such a hook-up and state if the two finishing ends of both phases or the start of one phase and the finish of another are hooked together. On what principles will the motor operate?
Chicago, Ill. J. H. B.

In the October issue J. H. B. does not give sufficient information concerning the present winding of his two-phase motor. When changing a motor from one phase to another, it is essential to have complete information concerning the original winding, on which to base calculations.

I have used the accompanying diagram to convert a two-phase, six-

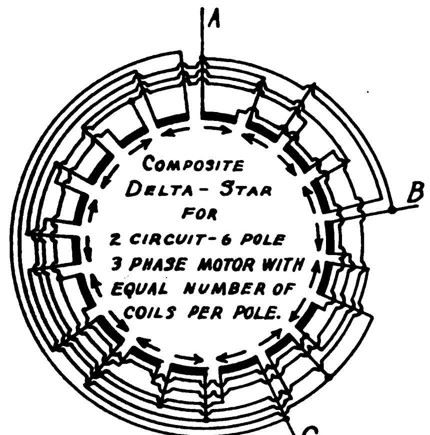


Diagram used in converting two-phase, six-pole, two-circuit motor into a three-phase, six-pole, two-circuit motor.

pole, two-circuit motor into a three-phase, six-pole, two-circuit motor. This will not give a three-phase motor of the same characteristics as the two-phase connection but will approximate it very closely. The correct three-phase voltage for this connection will be approximately 5½ per cent higher than the rated two-phase voltage. The three-phase power rating will be about 80 per cent of the two-phase power rating on the same temperature basis. If the old motor is a 40-deg. motor with a two-hour overload capacity it will carry approximately 96 per cent of the two-phase power rating on a 50-deg. continuous rating.

For a four-pole motor the correct three-phase voltage will be approximately 97 per cent of the two-phase voltage and the power rating the same as above.

The above explanation is based on a winding that will have an equal number of coils per pole in each phase in both two- and three-phase connections. For motors having an unequal number of coils per pole there will be a slight correction.

CHARLES R. SUGG.
Electrical Engineer,
Atlantic Coast Line Railroad Company,
Wilmington, N. C.

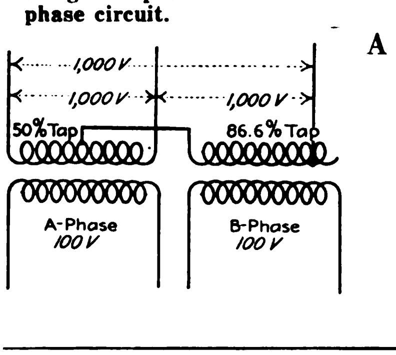
* * * *

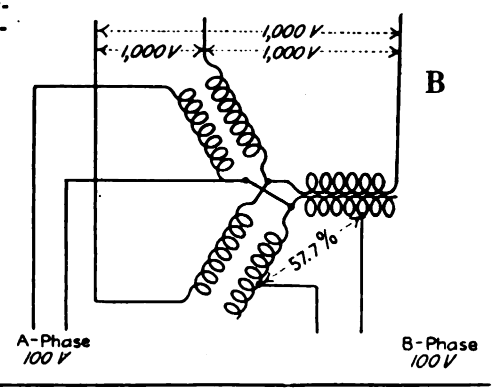
In answer to the question by J. H. B. in a recent issue, in order to operate two-phase motors on a three-phase system, use two transformers, one as a main transformer with a 50 per cent tap on the primary winding and the other as a teaser with an 86.6 per cent tap on the primary. With this arrangement it is sometimes possible to use a teaser transformer with a different ratio from that of the main transformer. For instance, if the ratio of the main transformer is 10:1 as shown at *A* in the diagram, a 9:1 ratio transformer may be used for the teaser. Then the tap on the teaser transformer will be 96.2 per cent of the total primary winding or, 86.6 per cent divided by 0.9. Then if the Scott connection is used, the three-phase primary at, say 1,000 volts, will give a secondary at 100 volts, two-phase, as shown.

Or three transformers connected in star, assuming 1,000 volts primary to 100 volts secondary, may be used by joining two secondary windings in series and bringing out leads at two points at 57.7 per cent of the windings for the *B* phase, with the other secondary winding brought out at full voltage for its phase, as shown at *B* in the diagram.

New Britain, Conn. H. S. RICH,

Transformer connections for operating two-phase motors on three-phase circuit.





Trouble with Commutator Grinding Machine—I recently ground a commutator on a 150-kw. generator with one of the finest tools made, manufactured by the Jordan Commutator Grinding Company, but I did not have much success owing to the rapid wear of the corundum wheel.

When I set the wheel against the commutator it cut a groove, due to the rapid wear of the wheel. Before I could move it an inch along the face with the lead screw the wheel was worn so badly that it would barely touch the commutator. I tried setting it up for very light cuts and turning the lead screw rapidly but that did not help any and it is not a first-class job. The commutator is 14 in., in diameter, 12 in. long and turns at 1,200 r.p.m. The corundum wheel turns at 2,880 r.p.m., cutting against the direction of rotation of the commutator, is ½ in. thick and was 8 in., in diameter at first but when the job was finished it was only 5 in., in diameter.

I should like to know if this trouble is commonly experienced.
New Orleans, La. P. B. A.

In reply to P. B. A's question in the December issue of INDUSTRIAL ENGINEER, at one time I experienced similar trouble and found that it was caused by too high commutator speed and vibration of the grinder holder.

I got excellent results by setting the grinding machine so that it was rigid, using turn-buckles and pipe to support it. The ¼-hp. motor was placed on a small track on a heavy packing box so that it could be moved along with the feed screw. If the motor is set stationary the belt tightens when the grinder is feeding across the commutator, unless a long belt can be used to connect the motor and grinder.

I found that the best results were obtained by revolving the armature or rotor about 75 r.p.m. in the same direction of rotation as the grinding wheel. I used a Jordan 7-in. x ½-in. coarse wheel turning at 2,500 r.p.m. for cutting and a fine-grain wheel for finishing at the same speed. To compensate for wear of wheel the feed shaft was set 1/16 in. closer to the rear of the commutator, using a three-step, V-shaped cone pulley on

the motor to increase the speed for worn wheels.

WILLIAM J. MILDON.

Electrical Engineer,
Madeira-Hill Coal Mining Co.,
Philipsburg, Pa.

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With regard to P. B. A.'s question in the December issue, the trouble which he has experienced with his commutator grinding machine is, I believe, due to the fact that the commutator is rotating entirely too fast. I gather that it was rotating at about 1,200 r.p.m. and at this speed it would wear and cut down the corundum wheel exactly as a disc of soft iron will, if rotated fast enough, cut through a steel rail or girder.

If he can slow down the generator to say 50 or 75 r.p.m., I think his trouble will cease. Of course, there is a possible chance that the wrong grade of wheel was used.

If the prime mover of the generator is an engine it will be a simple matter to slow it down. If it is a motor-generator set, then a water rheostat may be necessary using the generator as a motor and applying full voltage to the shunt field and cutting the resistance in series with the armature. This arrangement will give a strong steady pull and there will be no tendency to race.

Chief Engineer, PHILIP M. EMIGH.
Mountain Water Supply Co.,
Indian Creek, Pa.

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With reference to the question asked by P. B. A. in the December issue of INDUSTRIAL ENGINEER, it is very probable that the selection of the cutting wheel for the Jordan commutator grinder is the reason for a poor job. Emery wheels are rated in two different ways: first, as to grain or coarseness, and second, as to grade of hardness. Inasmuch as the job was rough and unfinished, it is evident that the wheel was too coarse and as the wheel wore down quickly it was probably too soft. A wheel ¾ in. or 1 in. wide would be preferable for a commutator of the size mentioned. When grinding a commutator it is better to use a coarse wheel to start with and later finish with a finer wheel for the sake of smoothness and appearance.

General Electric Co., L. B. MORRILL.
Boston, Mass.

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I read with interest P. B. A's question in the December issue regarding trouble encountered in grinding commutators with a Jordan grinder. I have used this make of grinder on quite a number of machines, but on most occasions have experienced the same trouble that he did. If the commutator is long the wheel will chatter and wear down before a cut across is made.

On one occasion I had to grind a 200-kw., 80-r.p.m. generator which had a commutator 14 in. long and 35 in. in diameter. When I tried to grind it I found out that the wheel wore too fast to make a straight cut across. After deliberating for a while I hunted around until I found a compound steady rest from an old lathe. I put this lathe rest, or carriage as some call it, on a 10-in. x 8-in. timber placed across and bolted to the bedplate. Then I mounted the grinder in the tool post of the rest and operated it as a lathe tool. After that I had no more trouble with the grinder and made a nice, even job of grinding the commutator. I hope this account of how I overcame the trouble will be of some help to P. B. A.

NICHOLAS J. WEISS.

West New York, N. J.

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Equalizing Large Generators—I should like to have some reader of INDUSTRIAL ENGINEER tell me how to go about equalizing two 112-kw., 250-volt d. c. engine-driven generators and two rotary converters which furnish power at the same voltage. One of the converters is rated at 150 kw. and the other at 300 kw. They are supplied with alternating current from a public utility company and are modern units of up-to-date design. The engine-driven units are old-type, four-pole machines. I should like to equalize these units by means of resistance shunted across the series field. What losses would be incurred by this method of operation? How should the proper value of the resistance be determined?
Cincinnati, Ohio. R. G. P.

Answering the question asked by R. G. P. in the December issue, I would say that equalizing large generators should present no unusual difficulty when using the series field shunt he mentioned.

There may be some cross current at times due to the fact that the neutral point on the engine-driven generator shifts with the load and remains practically constant on the rotaries. I do not know of any method whereby the exact value of the resistance can be determined except by "cutting and trying."

Usually, German silver or a similar alloy is used in strip form. This comes in lengths of 100 ft. or more. The proper amount to use is found by trial and the balance returned for credit.

In practice, the following method may be used to obtain a flat-compounded generator: Connect one end of the strip to one end of the series field, making a permanent connection. Unroll, but do not cut off, 6 or 8 ft. of the resistance and *clamp* it to the other end of the series field coil. Next start up the generator and measure the exact voltage at no-load, and at ¼-, ½-, ¾- and full-load. If the voltage at full load is higher than the voltage at no-load, shorten the series shunt and try again until the voltage remains constant. Next, cut off the remainder of the roll of resistance leaving about 12 in. projecting beyond the temporary clamp. Follow the same method with the second rotary or generator. When this is done, test them for correct polarity using two lamps or a volt-meter of twice the voltage rating of the busbars.

If the voltage and polarity are correct, close the equalizer switches first, the series coil switches (positive) next and the negative switch last. The circuit breaker should be placed in the negative lead.

Now try the machines again at no-load, and at ¼-, ½-, ¾- and full-load. If their characteristics are approximately the same, which is very rarely the case, each machine should take its proper share of the load. If one machine takes more than its share, proceed as follows: Increase the resistance of the path through the series field coils of the machine taking too much load until the load is divided between the machines in proportion to their capacities. Usually only a small increase in resistance is needed. The increase in resistance may be provided by inserting a longer conductor between the generator and the busbar, or iron or German silver washers may be put under a connection lug.

If the generators have different compounding ratios it may be necessary to readjust the series field shunts to obtain uniform conditions. This explains why an extra foot was left on the series field shunt resistance.

The resistance strip used should be heavy enough to carry a large portion of the total load of the machine, although it may never be called upon to do so. Inasmuch as this method of equalizing is in every-day use, I do not believe that there is much loss in connection with its use. PHILIP S. EMIGH.

Chief Engineer,
Mountain Water Supply Co.,
Indian Creek, Pa.

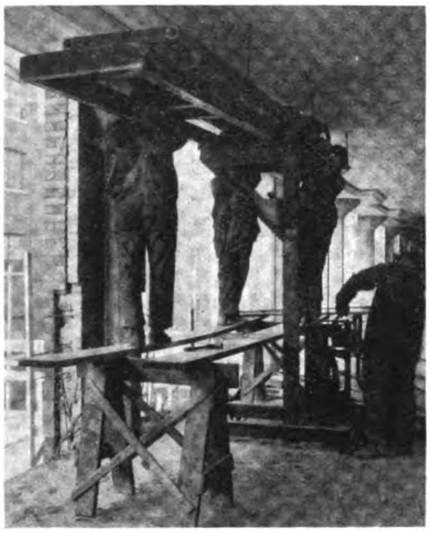
Building Maintenance and Plant Safety

The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Helps in Erecting Radiators, Lineshafts or Motors on Ceilings

ERECTING or dismantling ceiling radiators, heavy pipelines, lineshafts, pulleys, or other similar equipment and placing or removing overhead motors—and almost every shop has considerable new work and alterations of this kind—is a task because of the difficulty in lifting the heavy pieces to the ceiling. Ordinarily, a chain hoist, even if it is possible to attach it to the ceiling, will lift these objects only part of the way. The plan used in some new construction work, as shown by the accompanying illustrations, enabled a smaller gang to do more than double what had been considered possible under former methods of construction. This same plan could be used for dismantling also.

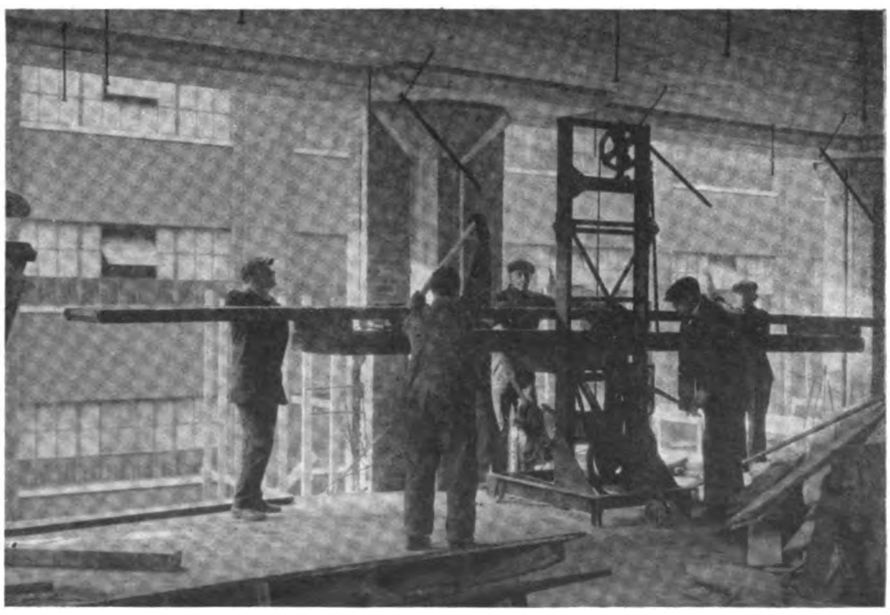
In this case, hand-operated tiering machines (Economy Engineering Company, Chicago, Ill.) with an inverted platform were used so as to support the work close to the ceiling until it could be fastened. The first step is to build a long cradle of about 4-in. by 6-in. timbers. This is balanced on, and bolted to, the tiering machine platform. During the assembling of the radiator, say, the ends of the cradle are supported on horses which hold the platform at a convenient height for working. These horses, if of the right height, may be used by the men to stand on later, while fastening the radiator to the ceiling. It is best to elevate slowly at first and test to see if the load is in balance and will not tip.



Overhead work may be speeded up by using a tiering machine to raise and hold the work at ceiling.

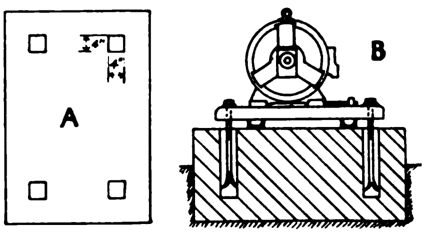
Lengths of lineshafting may be erected or dismantled in the same way. If solid pulleys are attached to the shaft before it is erected it will be necessary to block the shaft up on the wooden cradle so that it will be at least approximately level. Another time and labor-saving application is to use the machine to place or remove overhead motors.

Tiering machines with inverted platforms, such as this, are special and not ordinarily used for piling or tiering material in industrial plants because the platform does not go low enough. The standard type of platform which lowers almost to the floor may be used by building a special box-like extension to it so that the top of the box, when it is at its elevated position, will reach near enough to the ceiling.



Providing Means for Making Foundation Anchor Bolts Adjustable

IN THE September issue of INDUSTRIAL ENGINEER, Frank Harazim described on page 458 a simple method of making anchor bolts adjustable. A method which we have adopted and found very convenient for accomplishing this purpose when making motor installations may be of interest.



When the foundation is laid four square holes are made in it by the use of wooden mandrels. The motor with the anchor bolts is then put into position, resting on channel irons, and the holes filled with concrete.

When the foundation is laid it is provided with four square holes, as shown in *A* of the illustration. These holes are, of course, located to conform to the motor anchor bolts. For making these square holes we use a set of four wooden mandrels approximately 4 in. square, which will serve in almost every case.

The motor, with the anchor bolts, is placed in its final position on two small channel irons laid across the foundation, as shown in *B*. Then the holes are filled with concrete.

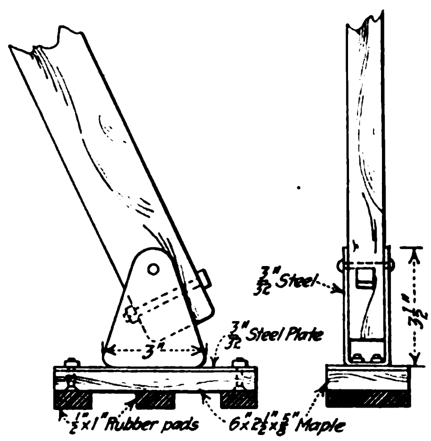
When the concrete has set the channels are removed and the motor is let down. If the motor does not set level very thin iron plates may be used to raise the low end. The foundation is then finished all over with cement. We have used this method with satisfactory results in installing motors up to 200 hp. in size.

P. VAN HERK.

Bressany, Belgium.

Rubber Pads on Easily Constructed Safety Shoe for Shop Ladders

SLIPPING LADDERS are often the cause of a serious accident. To prevent this, one company uses shoes on all shop ladders, as shown in the accompanying sketch. These shoes are made from two pieces of 3/32-in. steel, a block of hardwood 5/8 in. thick, preferably maple, and 3½-in. by 1-in. rubber pads, 2½ in. long. The U-clamp is bolted to the flat steel plate, which prevents the maple block from splitting. The rubber pads should be glued on to the maple block, as well, or fastened by tacks or screws to prevent them from loosening.



One of the advantages of this shoe is the light weight and the fact that it can be used on almost any type of flooring. Another advantage is that the ladder can be swung in either direction.

Treating Concrete to Make Floor Surfaces Withstand Excessive Wear

IN MANY plants the concrete floors dust and wear away quite rapidly where they are subjected to heavy trucking. In the Brooklyn, N. Y. plant of the Englander Spring Bed Company, shown in the accompanying illustration, this problem has been solved. In this plant 200-000 sq. ft. of treated floor has been in use over a period of four years and has carried over 1,000,000 tons of traffic without showing signs of excessive wear.

These floors have been prepared by a special "Master Mix" treatment (The Master Builders Company, Cleveland, Ohio) which, it is claimed, not only makes them dustless but more resisting to wear. Here the treatment is applied in the topping layer. In treating these floors a 1-in. treated topping is recommended. This is made in the proportion of two parts of clean fairly coarse sharp sand to one part Portland cement and mixed thoroughly dry.

Next "Master Mix" is added to the gaging water gradually in the proportion of one gallon for every barrel of cement used. The cement is poured, floated and troweled in the usual manner. A second coating when the surface is sufficiently set will produce a hard smooth finish. The next step is to protect the surface of the cement from injury and keep it wet until the surface is hard. A layer of soft-wood sawdust, properly wet down, serves admirably for this purpose. This may require several wettings during this process, depending upon the atmosphere and the circulation of air, if the floor is in an enclosed area.

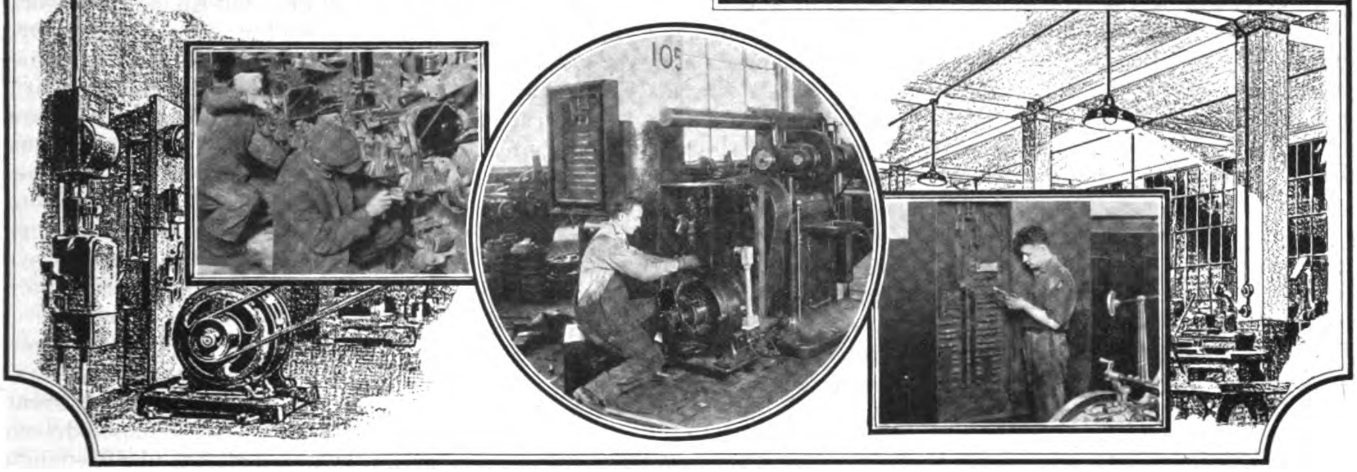
This concrete floor was specially treated to resist wear.

At the Brookyn plant of the Englander Spring Bed Company 200,000 sq. ft. of specially treated floor surface has handled over a million tons in four years.

Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.

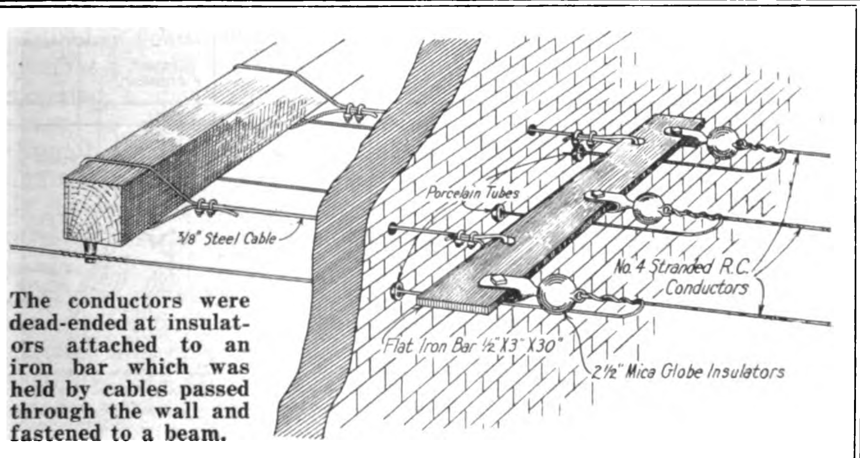


Easy Way of Dead-Ending Heavy Conductors at Old Wall

IN RUNNING a No. 4 line to supply a three-phase motor operating a sand cutter in a foundry it was considered advisable to avoid putting any strain on the outside wall of the building; this wall was only 12 in. thick and not very solid. Inasmuch as the line was quite long and rather tight, it was decided to anchor it to the first cross-beam just beyond the wall. This was done by dead-ending the three wires at globe insulators fastened to an iron bar 30 in. long, 3 in. wide and ½ in. thick, which was held just outside the wall by two steel cables ½ in. in diameter, which were passed through the wall and clamped around the nearest heavy cross-beam. Mica globe insulators with a clevis on one side and a ¼-in. eye on the other were used. The clevis was fastened to the flat iron bar by a ½-in. bolt. The steel cables were drawn through holes in the bar, which were well beveled to avoid cutting the strands, and double clamped.

The conductors were then carried through the wall in porcelain tubes and to the desired location, cleated to beams. By this scheme it was possible to keep the line tight without putting any strain on the wall.

New Britain, Conn. H. S. RICH.



The conductors were dead-ended at insulators attached to an iron bar which was held by cables passed through the wall and fastened to a beam.

Points to Be Watched When Wiring for Motors in the Industrial Plant

MOTOR wiring problems in the industrial plant should be considered from the standpoint of safety, reliability, flexibility, and efficiency. Refinements in construction due to the consideration of safety features are receiving much more attention at present than in the past, and their value is self-evident. The comparative importance of the item of reliability, which deserves more attention than it receives, depends upon a number of factors but particularly upon the quantity of production interrupted or the loss to the manufacturer when the machinery stops.

As an example, in one plant in which power for twenty operators is furnished by one motor, $130 per motor covers the entire cost of the equipment installed, including motor, belt, control and wiring. With an allowance of 25 per cent as the total annual charge-off for depreciation and obsolescence, the equipment charge per year is $32.50 or about ten cents a day for a single motor and its auxiliary fixtures. In contrast to this, the wages of the twenty operators dependent upon this single motor amount to $10 per hour. Thus a refinement in construction that will prevent three 20-minute shut-downs per year at a labor cost of $10 would warrant an increase in the initial cost amounting to about 30 per cent of the total; in other words, an additional initial expenditure of $40 charged off over four years or at the rate of $10 per year would be justified if it saved only one hour of time per year lost through shut-downs. Inasmuch as the wiring and installation cost amounted to approximately 40 per cent of the total cost of the motor equipment, 30 per cent of the total cost would be approximately 75 per cent of the wiring and installation cost. Thus it pays to get reliable equipment and material and by installing it properly decrease the

likelihood of failure. In a plant in which the cost per motor per operator is greater or less, a proportionate increase or decrease in expenditure for preventing interruptions would be warranted.

In determining the economical size of wire, above the minimum requirement as determined by the Code and other regulations and the permissible voltage loss, the probable life of the installation, as well as the number of hours per year the "energy saving" will be operative, should receive very careful consideration. The load factor is another important item and should be given due weight. In some plants the load factor is such that wiring mains large enough to handle the peak load are larger than the economical size for the average maximum load.

The possibility of costly interruptions of production as the result of the improper failure of a fuse or the opening of a circuit breaker renders advisable, in so far as practicable, the elimination of this equipment. One method of accomplishing this is by so designing the mains as to eliminate cutouts intermediate between the main switchboard and the motor. Further, such fuses, circuit breakers and control devices as are necessary should be placed where they will be readily accessible at all times. Also, from the standpoint of reliability an automatic circuit breaker, or a combination of an automatic circuit breaker and fuses frequently gives better service than fuses alone. In this construction the fuses are of such size as to blow only in the event of the failure of the automatic overload device. Automatic overload and no-voltage protective devices, especially for alternating-current motors, in convenient, enclosed form are available at a cost not exceeding and often less than that of fuses, when the saving resulting from the use of the circuit breakers is taken into consideration.

In determining the minimum permissible size of the main, allow ample provision for the maximum possible load. With a group of motors in which the control is such that only one motor can be started at one time, the maximum load is usually at the time of starting the motor with the heaviest starting current when all other motors of the group are running under full load. In general the wiring mains should be of sufficient capacity to provide for the simultaneous starting of as many motors as can be started together even though all other motors of the group are running under full load. Thus a line of No. 6 B. & S. gage mains may be sufficient for a group of small 550-volt, three-phase motors with an aggregate rating of 40 horsepower, and yet be insufficient for a single, heavy-starting motor not exceeding 20 hp. rating. These considerations are also of extreme importance from the standpoint of reliability.

Reliability and continuity of service require wiring of ample capacity, proper size of protective devices in accessible locations and adequate protection of these devices from mechanical injury.

Worcester, Mass. C. W. KINNEY.

Quick Method of Synchronizing Generators After Excitation Failure

SOME TIME ago I had an interesting experience in a hydroelectric power station where I was employed as an operator.

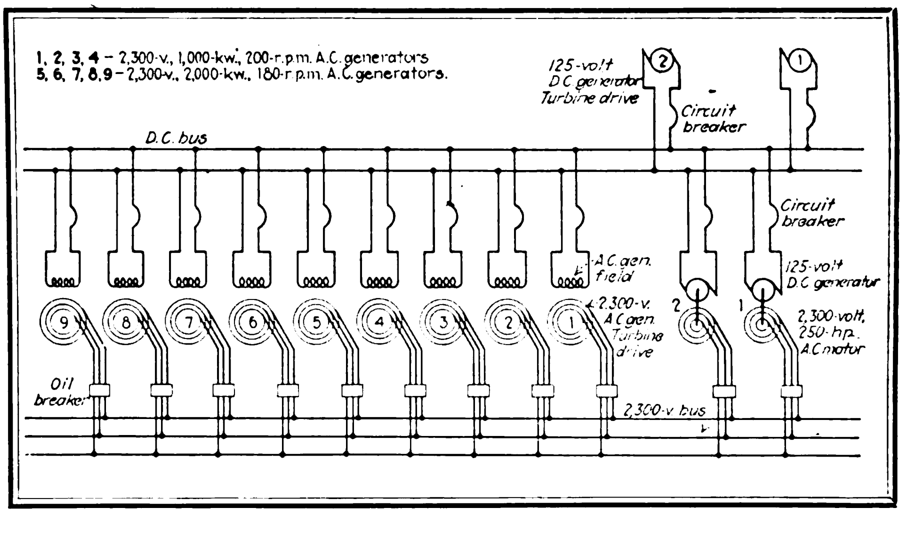
As can be seen from the illustration, the generating equipment consisted of two turbine-driven, and two motor-driven, direct-current exciters. The motors of the latter were fed directly from the 2,300-volt main bus. The four exciters could be operated in parallel with the d.c. bus which fed the a.c. generator fields. The turbine-driven exciters were used only for starting when the entire plant was down. There were knife switches and carbon circuit breakers in all the circuits leading to the d.c. bus, as well as in all a.c. generator field circuits leading from it.

When the motor-driven exciters were tripped off the line, service was restored by starting up one turbine-driven exciter under the load of the generator fields. As the exciter voltage built up, the generators pulled into step.

The a.c. equipment consisted of four 1,000-kw., 200-r.p.m., 2,300-volt, and five 2,000-kw., 180-r.p.m., revolving-field a.c. generators, turbine-driven and controlled by Lombard governors. All of these generators fed into the one 2,300-volt bus through disconnects and oil circuit breakers. Under normal operation, the generator field current was supplied by the two motor-driven exciters. A Terrill voltage regulator was used to control the voltage.

On the occasion referred to, seven of the nine a.c. generators were running. The generator field current was supplied by No. 1 motor-driven exciter which had just about enough capacity to carry the load. Motor-generator No. 2 had been down for repairs. When starting it the floor man closed the compensator running switch before the starting switch was out. This, of course, short circuited the compensator, the short blowing off the cover. The running switch for No. 1 and the starting switch for No. 2 motor-driven exciter were located rather close together and when No. 2 shorted it not only went to ground but also shorted across the No. 1 running switch. The relay on No. 1 motor-generator immediately tripped the switch, leaving the seven a.c. generators running without fields and connected to the bus. The speeds of the generators, when running without fields, varied all the way from half-synchronous speed to about 65 per cent over synchronous speed.

To restore service in the shortest possible time the carbon circuit breaker on motor-driven exciter



No. 1 was opened, clearing it from the d.c. bus. The carbon circuit breaker on one of the turbine-driven exciters was closed. This exciter was then started with all the circuit breakers on the a.c. generator fields closed and the seven generators still running and connected to the a.c. bus. It took over 80 per cent gate opening on the exciter turbine for the d.c. voltage to build up, but as soon as it approached normal the a.c. generators pulled into step and did not have to be synchronized.

Service was thereby restored and the station was ready to carry full load in less than 2 min., while it would have taken at least 15 min. to synchronize all of the seven generators in the normal manner.

Possibly some other readers of INDUSTRIAL ENGINEER have had a similar experience. I would be interested in learning what they did in the emergency and whether they think my method would be likely to damage the equipment. Let us have a discussion of this through the pages of INDUSTRIAL ENGINEER.

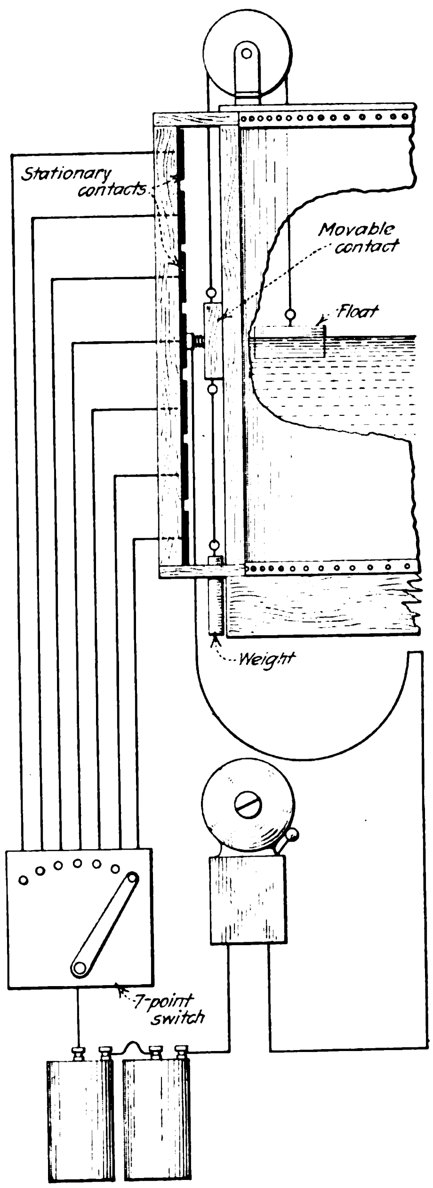
Belleville, Ont. J. H. GALLANT.

Float and Bell Device for Indicating Level of Water in Tank

A LARGE water tank located on the top floor of a factory building is supplied by two deep-well pumps located in the basement. Sometimes one pump is sufficient to keep the tank full of water; at other times both pumps are required. As a convenient means for keeping track of the varying water level in the tank, so that it may be known whether one or two pumps should run, the signaling system shown in the accompanying illustration was installed.

Instead of the usual indicator attached to the line connecting the customary float and weight, this device has a wooden block on which is mounted a moving contact in the shape of a copper stud passing through a spiral spring which bears against the collar on the contact end of the stud. The other end of the stud is inserted in a hole in the block.

As the water level changes, the moving contact closes the circuit through the various stationary contacts which are mounted on a wooden upright. The stationary contacts, of which there are seven, are made of copper strips ½ in. wide and 1/16 in. thick. A wire leads from each contact to a corresponding button on a 7-point switch mounted in the engine room. As shown, the arm of the 7-point switch is connected to the battery and bell; the other side of the bell is connected to the moving contact, which



A movable contact, whose position is controlled by a weight and float, closes the bell circuit at various water levels.

By shifting the arm on the 7-point switch the approximate water level may be determined, or by setting the arm at the point corresponding to any desired level the bell will be rung when the water has reached that level.

is actuated by means of the float and weight.

In operation the switch lever is set on the right-hand contact button and both pumps are started at maximum speed. When the tank is full and the movable contact is in touch with the bottom stationary contact, the bell rings. The switch lever is then shifted to the second contact from the right, one of the pumps is stopped and the speed of the other is checked somewhat. If the alarm is again sounded, the pump in service is speeded up, or the other one is started.

The engineers strive to keep the water in the tank at a level corresponding to a position between the two lower stationary contacts. If the water should drop below the level at which the bell circuit is closed through the second switch contact, the actual level can be found by shifting the switch lever to the left until the bell rings. A. J. DIXON.

St. Louis, Mo.

Two Methods Which Keep Tape on Conductors From Loosening

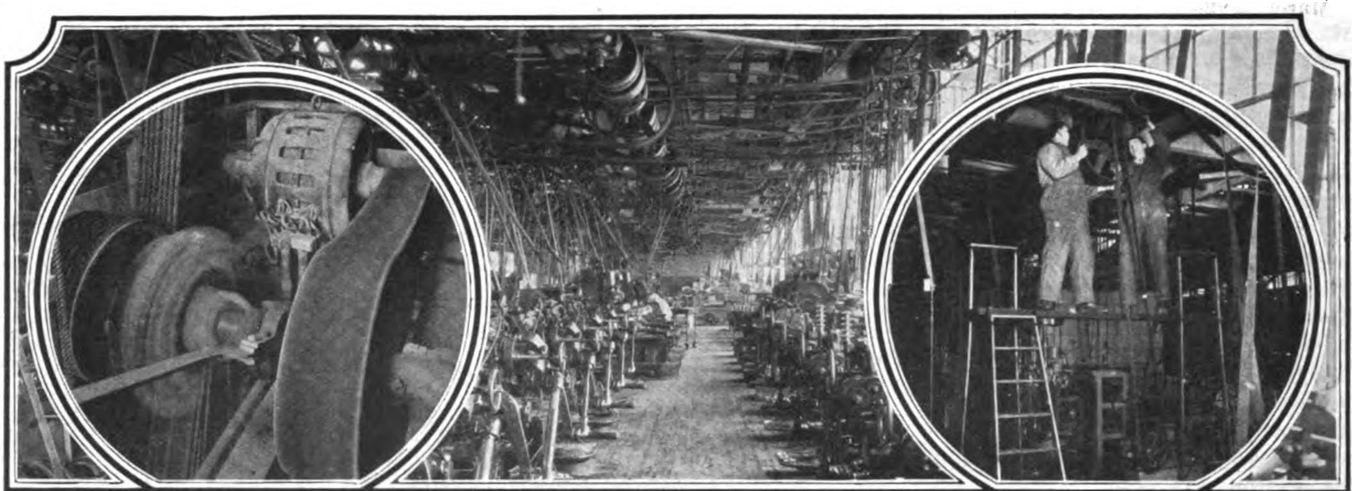
WHEN cables are brought up to the connection lugs at switchboards they are covered with friction tape. After being wrapped around the cables the tape is painted or varnished, both to give it a smooth surface to which dust and dirt will not adhere and to prevent it from absorbing moisture.

But in order to keep the tape clean it must be wiped down from time to time. Unless the tape wrapped on the cable is of unusually good quality, and the quality of the various makes of friction tape on the market varies more than does the quality of most electrical material, it will soon begin to dry out and lose much of its ability to stick to the cable or the other wrappings of tape.

Even good friction tape will become loose if it has been carelessly wound on. Also, the continual wiping down of the cables helps to loosen the wrappings, especially at the ends. This often results in an inch or two of the tape becoming loose at the end and hanging down. When conditions become too bad the loose end is cut off, but after a while more of the tape unwinds and has to be cut off. Eventually new tape may have to be applied.

There are two ways of preventing loosening. One way is to wrap the last turn loosely at first and pull the end of the tape down underneath it before giving it the final tension. The other way is to leave the end of the tape on the outside of the wrappings, but later tie it in place by binding around it several turns of strong, but soft and light, linen twine. G. H. McKELWAY.

Westfield, N. J.



Mechanical Maintenance of Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Emergency Method to Shorten Interruption of Service From Drive Failures

WHEN a motor driving a lineshaft in the plant of one Cincinnati machine tool manufacturer gives out for any reason, the interruption of service is only temporary. Extra motors with starting equipment are mounted on lift-truck platforms and can be taken to any lineshaft in a few minutes. An extra pulley is so placed on each lineshaft that the special motor on the platform may be deposited at the edge of an aisle at right angles to the shaft and the pulleys will be in line. Each motor has its own belt and as the lineshaft speeds are standardized, any motor will drive the shaft at the proper speed. Emergency leads are connected in and the group of machines can be going again in a few minutes.

The motor which gave out can then be inspected and removed if necessary. If it can be placed back in service shortly the extra motor is used until the repair is made; otherwise, either it or another motor is installed, on over-time if necessary, so that it does not interfere with the use of the production machines.

These extra motors and starting equipment are used, when not required for emergency service, to drive large machine tools when "working in" or fitting the bearings before sending out to the customer. In an emergency, one of these motors can be taken away from this work without anywhere near as large a loss as would be caused by the stopping of a lineshaft driving a group of production machines.

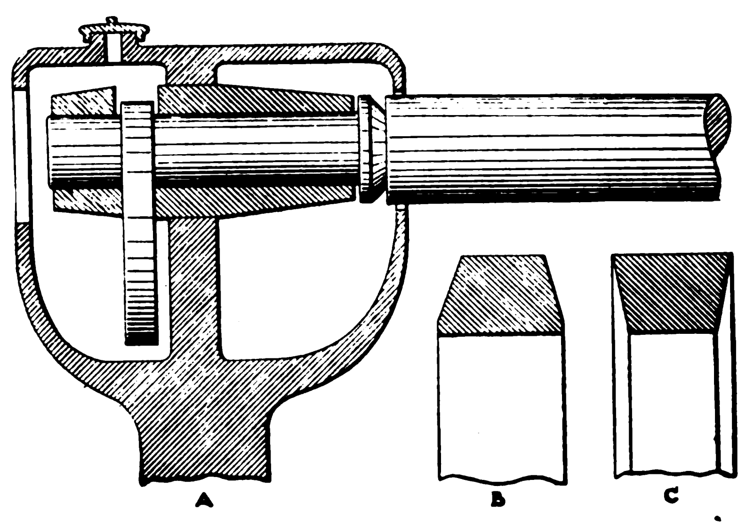
Chicago, Ill. F. E. G.

Beveled Sides Prevent Sluggish Action of Oil Rings

SLUGGISH action of oil rings, leading to improper lubrication of motor bearings, was cured after considerable searching for the cause of the trouble by beveling the sides of the rings of motors made in one factory. On testing these motors it was noticed that the ring would creep along at a very slow speed, two or three revolutions a minute on a machine of several horsepower, instead of the regular speed of about thirty to fifty revolutions. Although all journals and rings were made in large numbers and as nearly alike as possible, this trouble appeared on about one machine out of ten and disappeared nearly every time a new ring of the same size and shape was put in. Sometimes, of course, it was due to the ring rubbing against some projection on the casting, but more often no apparent cause was found by the assembling department.

At that time the oil rings were cut from a rather heavy brass tube with straight sides (see *A* in the illustration), making the cross-section rectangular in shape while the

The rings are beveled on either the inside or the outside to prevent them from sticking to side of oil ring slot.



journals had a straight slot 0.02-0.025 in. wider than the ring.

It was finally discovered that under certain conditions the ring would start with the machine and perhaps come up to normal speed but soon work itself toward one side of the slot and slow down, hugging closer and closer until there was only a very thin film of oil between the ring and the flat part of the journal.

Therefore, in an attempt to prevent sticking, three rings were removed and their sides were slightly beveled, as in *B* of the illustration. Then the trouble entirely disappeared. Since that time all oil rings are beveled either from the outside or from the inside, as at *C*, and there has been no sticking.

PHILIP G. BERNHOLZ.

East Orange, N. J.

Easy Way of Mounting Motor to Release Floor Space

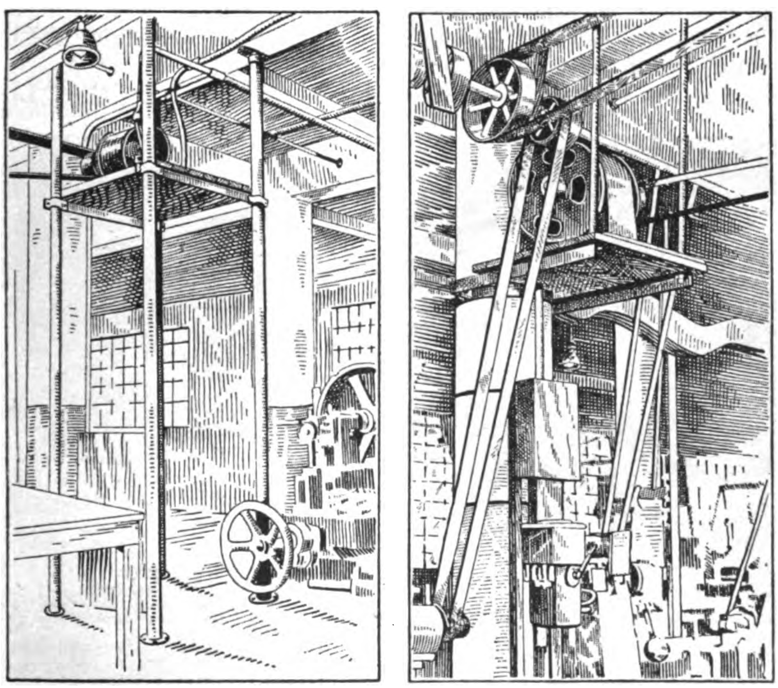
ECONOMY of floor space and convenience of control are now being obtained in one industrial plant by attaching the motor stand and control apparatus directly to the building columns, instead of mounting the motors on four iron pipes extending from the floor to the ceiling, as was formerly done. As the old supports were about 4 ft. apart, about 16 sq. ft. of factory floor space was wasted. In addition the supports usually interfered with the transportation of material.

The improved support is constructed by joining two half-circle iron bands around the column by means of bolts so that they cannot slip and attaching horizontal angle-iron pieces to the joints. The other ends of the angle-iron pieces are held in place by means of vertical ¾-in. rods attached to the ceiling. The motor is set on a wood platform built on the framework.

The switch box containing fuses and the motor starter can now be mounted on the column directly beneath the motor, so that considerable overhead conduit which was formerly used between the starter and motor is avoided. The motor can be easily cleaned and its location affords convenient inspection.

New York, N. Y. J. S. T.

The motor and control equipment are mounted on platforms which are supported by iron bands around the building columns and by rods from the ceiling.



Flat Spot on Driving Pulley Causes Trouble

SOME time ago we experienced a great deal of trouble with excessive sparking at the brushes of a generator. This case of trouble was so unusual that an account of what was done to prevent the sparking and how the real cause was finally discovered may be of interest to readers of INDUSTRIAL ENGINEER.

The generator was a 16-kw., 125-volt, 1,250-r.p.m., direct-current machine. When I found that I was not able to stop the sparking, I wrote to the editor of a well-known electrical magazine for suggestions. His reply stated that sparking might be due to one or more of the following causes: (1) Brushes not properly sanded; (2) brushes out of line; (3) too much vibration; (4) bearings worn so that armature is not centered between pole pieces; (5) high mica.

I checked up these points, but the sparking gradually became worse, and finally the generator had to be shut down because of excessive heating of the commutator. On my suggestion, an expert repair man was called in to test the generator for grounds and other defects. He said there was a ground in either the armature or commutator and, as there was no repair shop in town, the commutator was carefully removed and sent to a large shop in a nearby city. This shop reported that the commutator was in good condition and advised us to send them the complete machine for overhauling.

After going over the generator carefully, they were unable to find any defects and sent it back. But when it was placed in service again, the old trouble was just as bad as ever and the machine soon had to be shut down. At this time the generator was supported on wooden blocks which were bolted to the engine room floor. The floor had been blocked up underneath the generator and seemed to be very solid. The manager of the plant decided, however, to put the generator on a concrete foundation, as it was thought that vibration might be the cause of the trouble. But when it was placed on the new foundation, the generator behaved no better than it had before and had to be shut down again after running for only a short period.

An expert from another city was then called in and after a thorough inspection reported that there were no grounds present. He lined up and spaced the brushes and advised that the bearings be rebabbitted, the machine bolted down firmly, the commutator tightened up and turned down, and the belt straightened or replaced, as it was running somewhat out of line. All of this work was done, but when the generator was again put in service it ran very

little or no better than before. In addition, the brushes cut the commutator badly. As a possible remedy, we undercut the mica and installed a comb grounded to a water pipe for draining static electricity from the belt; all without results.

Soon the commutator had to be turned again, and this time the pulley was put in the lathe at the same time. We were using a paper pulley and found a small flat spot on it, so 3/32 in. was taken off.

After the commutator was turned down the generator was assembled and put in service, and we found to our surprise that all of the trouble had disappeared. The generator ran perfectly with no sparking or heating of the commutator. That was over two years ago and the machine is still running with no trouble whatever. We have often asked ourselves why we did not think about the pulley before. I do not know why we did not think of it as a possible source of trouble. This incident did, however, impress on all of us the fact that in practical engineering work the little things are sometimes the most important.

WALTER W. P. SINCLAIR.
Medicine Hat,
Alberta, Canada.

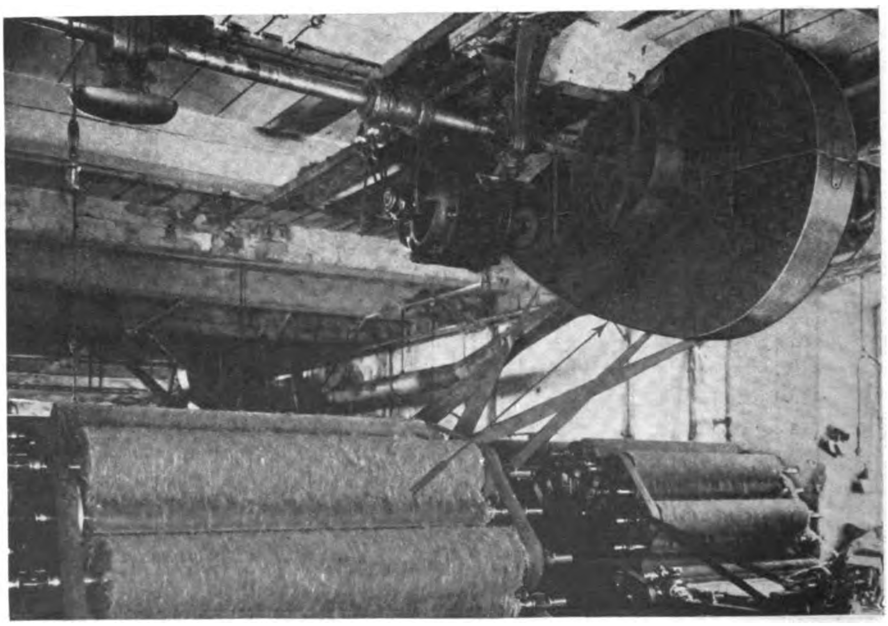
Savings Made With Silent Chains on Lineshaft Drives in a Textile Mill

FORMERLY eleven steam engines distributed about the Falls Schuylkill Mill drove lineshafts operating the various groups of textile machines. This system has been almost entirely replaced by smaller groups, each driven by a motor connected to its lineshaft through a silent chain. When this change was made the eleven engines and boiler rooms were replaced by one modern power plant with a consequent saving of the wages of six engineers and ten firemen. Also the single power plant gives better operating economies. In addition, much of the heavy friction load of the large lineshafting required for engine drive was eliminated by the subdivision into smaller groups.

On this installation motors operating at 1,700 r.p.m. drive the lineshafts at 105 r.p.m. This reduction is obtained through the sprockets and chain only and without any intermediate countershaft, as would be necessary with belt drive. If slow-speed motors had been used they would have increased the cost. Also the motors were placed close to the lineshaft; in one type of drive the distance between centers is only 3 ft. 6 in., while if a belt were used the distance would need to be about 8 ft. to 10 ft.

The silent chains (Link-Belt Co., Chicago, Ill.) require but little attention except for lubrication. They also run slack which lessens the friction on the bearings. Some of the chains have been in service about ten years at loads above their rating and are still in good condition.

ROBERT CALHOUN.
Chief Engineer,
John & James Dobson, Inc.,
Philadelphia, Pa.



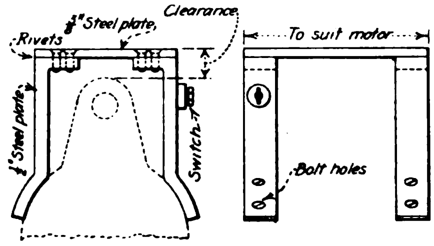
One of the group drives of the Falls Schuylkill Mill.
In this mill a large number of groups, each driven by an individual motor and Link-Belt silent chain, have supplanted eleven steam engines, each with its boiler room, driving large lineshafts. The large speed reduction—1,700 r.p.m. to 105 r.p.m.—is obtained directly without countershafting or other auxiliary reduction units.

Simple Method of Bracketing a Small Motor to a Bench Lathe

DIRECT motor drive for the bench or hand lathe is a worth-while convenience, particularly where considerable work is done and the operator depends on foot power to drive the lathe. In some small shops which actually have only occasional use for a power-driven bench lathe, a larger lathe than necessary is used because a power drive for the small lathe means installing shafting and pulleys at considerable expense.

It is possible, however, to apply individual motor drive to the small lathe by means of a simple method of bracketing, as shown in the accompanying illustration.

The bracket can be quickly and inexpensively made by bolting four steel-plate supports or legs to the headstock of the lathe. The plates should be about ½ in. thick and should be bent at the lower end to



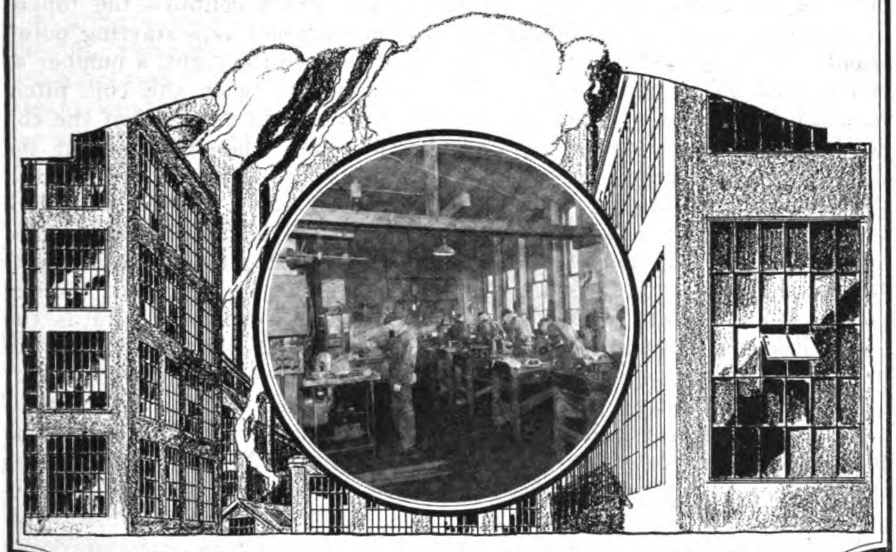
Four legs made of steel plate are bolted to the headstock of the lathe and support a platform which is large enough to receive the motor base.

conform to the shape of the headstock. These legs support a base plate of ⅜-in. steel which is fastened to the supports with machine screws. The motor, which will be about ¼ or ½ hp., should be bolted to the plate. A short belt drive is used and, if a step pulley is put on the motor shaft, speed changes can be made as usual by changing the position of the belt on the pulley.

A snap switch located on the motor bracket, or close to the lathe, and connected to the shop lighting system, will make it possible to operate the lathe independently of the other shop equipment. The convenience and simplicity of this installation will appeal to the user of a foot-power lathe, and in most cases the materials for making the bracket can be found in the shop.

G. A. LUERS.
Washington, D. C.

In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Simple Indicator for Locating Repair Men in the Plant

WE HAVE found the device which is shown in the illustration so useful for locating electricians and other workmen that it may be of interest to the other readers of INDUSTRIAL ENGINEER.

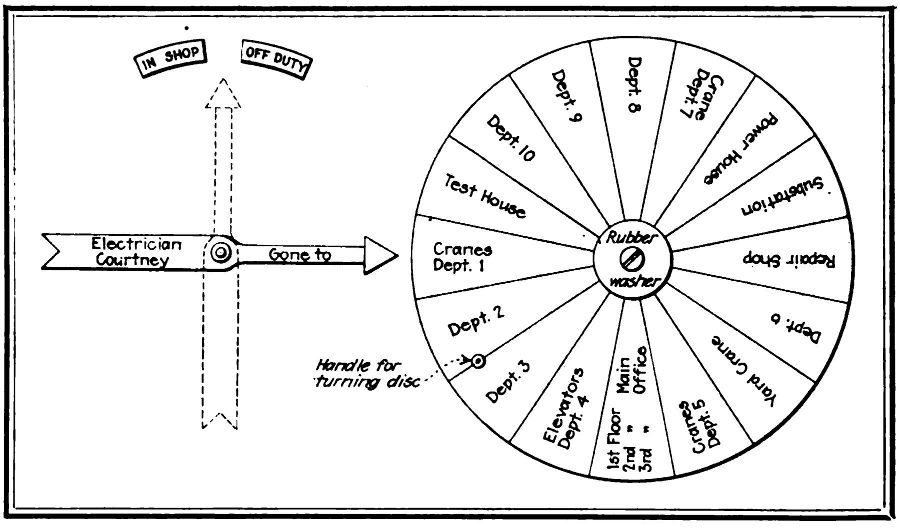
As will be seen it consists simply of an arrow and a round metal disk cr dial, which is divided into as many sections as there are departments in the factory. Both dial and arrow may be made of any suitable material, such as thin sheet iron, wood or fiber. A hole should be drilled through the center and the dial mounted, on a board or on the wall in any convenient location, by a screw so that it will turn freely. It is advisable to put a rubber washer back of the dial and one in front, before putting the screw in. The screw should then be tightened just enough to prevent the dial from being jarred out of position after it is once set.

The arrow, which carries the name of the workman, should also be drilled through the center and fastened in the same way as the dial, using rubber washers to keep it from turning too freely.

When in use the arrow should be set in the horizontal position and the dial turned around until the arrow points to the department where the electrician is working. When he comes back to the shop he sets the arrow in the vertical position; thus the shop foreman knows where he is.

Although the dial and arrow shown here are intended for use in the electrical department, they can, of course, be readily adapted for use in the millwright or other departments. ULYSSES F. COURTNEY.

Electrician.
Avery Company,
Peoria, Ill.



When the electrician goes out on a job he sets the arrow in the horizontal position and turns the dial until the arrow points to the department in which he can be found.

Motor-Driven File Lessens Work of Reaming Small Holes

AFTER reading G. A. Luers' article under the above heading, on page 607 of the December issue of INDUSTRIAL ENGINEER, in regard to using a motor-driven file to ream out small holes, I wish to point out one of the disadvantages in using the method he describes.

All of the round or "rat tail" files in my possession are cut with a right-hand screw pitch, and as an electric drill rotates in the same direction there is a tendency for the rapidly revolving file to be forced into the hole which is being reamed. If the hole is smaller than the largest part of the file disaster to the work, the file or the drill will follow immediately, unless the operator uses extreme care.

This statement is based on actual, and painful, experience.

Indian Creek, Pa. PHILIP N. EMIGH.

How to Find Commutator Pitch of Armature Coils with Test Lamp

IN A RECENT issue of INDUSTRIAL ENGINEER a reader asked for the best and quickest method of finding the commutator pitch of an armature coil with a test lamp. Perhaps a description of the method we use for this purpose may be of interest to other readers also.

On a lap-wound armature lift out of the commutator necks three adjacent top leads only; then apply one end of the test light to the middle top lead, making sure that the other two raised top leads do not touch it or the commutator. Then with the other test lead touch the bar on either side of the bar to which the middle top lead is connected. Only one bar will give a light providing, of course, that the winding is not completely burnt out and full of shorts. If a light is obtained when touching the bar to the right, the winding is single-lap progressive or left-hand; if the bar to the left lights out the winding is

single-lap retrogressive or right-hand.

If no light is obtained, however, on either side of the middle lead bar, this would mean a double-lap winding, right-hand or left-hand as above.

When checking the winding connection in this manner test between all raised leads and commutator bars to make sure that the section is free from shorts.

For a wave winding raise any three adjacent top leads as above and test for shorts; then with one test lead on the middle top lead, slide the other test lead around the commutator towards the bottom of the coil, or for a left-hand coil run the test lead in a clock-wise direction around the commutator and for a right-hand coil in a counter-clockwise direction.

One way a left-hand coil can be identified is as follows: Stand facing the armature at the commutator end; then if the top half of the armature coils are on your left the coils are left-hand, if on the right the coils are right hand. It is very important to get the direction of the test lead right on a four-pole motor as there are two lead pitches possible, that is, a long pitch and a short pitch, and by counting around one way one pitch would be had and then if a count is made in the opposite direction another pitch would result. The correct pitch is always found by moving the one test lead around the commutator towards the center of the coil to which the top lead is attached. Run the test lead around until a bar is reached that lights the test lamp; it should light on only one bar. This bar will be half-way around the commutator on a four-pole armature, one-third around on a six-pole, one quarter on an eight-pole, and so on. When this bar is located, mark it; then count over from the bar to which the middle top lead is connected. This will give the lead pitch. Then with one test lead still on the middle top lead try the other test lead on the bars on either side of the middle bar. If a light is obtained on the bar to the right of the middle bar, then, with a left-hand coil the winding is single-wave progressive. If the light is obtained on the bar to the left, with a left-hand coil, the winding is single-wave retrogressive. If no light is obtained on either bar, but the test lamp lights up when the test lead is put on a bar which is two over from the middle bar, or 1-3, either side, the winding is double (four circuit) wave.

The diagram illustrates the above method of testing.

When an armature is received completely burned out, that is, with turns and bars shorted, the following method of taking data can be used:

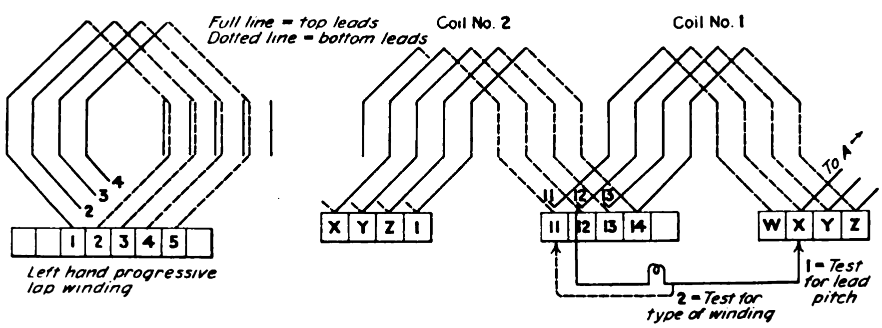
First remove hoods, if any, and all end- and core-bands and the core bands on the leads at the rear of the commutator. Then determine whether the coils in the winding are right-hand or left-hand. Select any one coil and mark it with white chalk, and also mark the commutator bar to which the top leads of this coil connect; then, if the winding is left-hand start to cut off the top leads only at the rear of the commutator, starting at the bar to the right of the bar to which the leads of the marked coil connect. Do not cut these leads. Remove all top leads three-quarters of the distance around the commutator. Next, estimate the coil pitch, which can be taken as the number of slots divided by the number of poles; use full-pitch figures. Then taking the slot which contains the top of the marked coil as a starting point, count over to the right, a number of slots equal to twice the coil pitch. Start to lift the top half of the coil in this slot; when possible cut the coil in two to enable it to be pulled out of the way. Proceed with each top half of coil, until enough tops have been lifted to enable the complete coils to be removed. When lifting coils work back towards the marked coil; as each top or complete coil is lifted or removed pull it around to the right on the commutator end as far as it will go, so as to expose the bottom leads. When removing complete coils cut the bottom leads of each coil as it is removed. Proceed as above until the marked coil is reached, which will then be completely exposed to view. It is then a simple matter to check the lead pitch and coil pitch.

For a right-hand winding work to the left. A. C. Roe.

Detroit, Mich.

Method of finding type of winding and commutator pitch of coils with test light.

On a lap-wound armature three adjacent top leads are lifted and one end of the test light is applied to the middle lead. The other end of the light is touched on the bars on each side of the bar to which the middle lead connects. If a light is obtained on the bar to the right the winding is single-lap progressive, or left-hand. A light on the bar to the left shows that the winding is single-lap retrogressive, or right-hand. The diagram at the left shows a left-hand progressive lap winding. The diagram at the right shows the method of testing for lead pitch and type of winding. Details of the method are given in the text.



How One Shop Repaired a Broken Oil Stone With Shellac

A HARD oil stone, one of the favorites in a small repair shop, was repaired recently, after it had been dropped and broken through carelessness.

Inasmuch as the breaking of oil stones is a more or less frequent occurrence, the method of repair used in this instance may be of interest.

The stone was cleaned of oil by wiping the fracture and the adjacent surfaces with alcohol and placing the two pieces over the top of a small gas heater. After the stone was thoroughly heated, and the oil had been driven off, powdered shellac was sprinkled over both faces of the fracture, where it melted and flowed into the numerous crevices. While hot, the two sections were fitted together and clamped in an idle milling machine vise.

The shellac hardened as the stone became cool and the junction was not visible. Apparently this method of repair restored the stone almost to its original condition, as it has been constantly used since then and the line of fracture shows no evidence of separation. In fact, the user of the stone can hardly tell it had been repaired. G. A. Luers.

Washington, D. C.

Rewinding a Large Generator In Thirty-three Hours

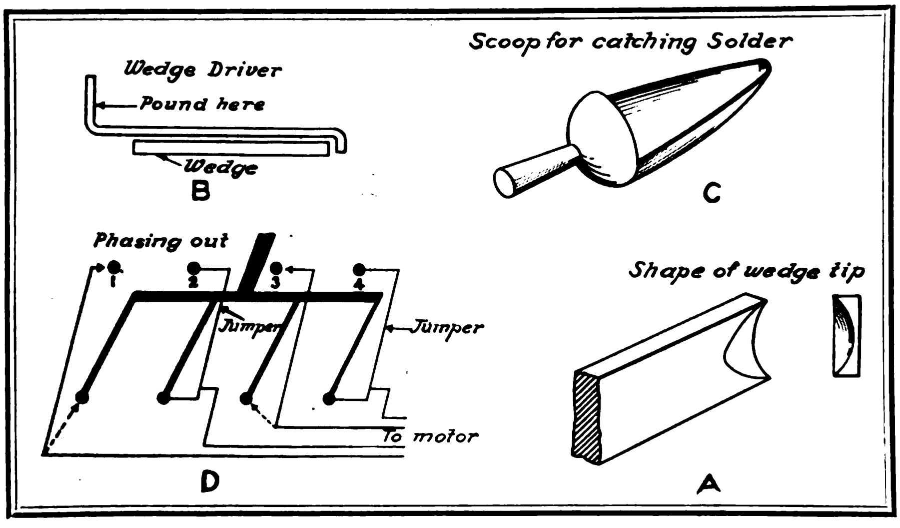
A LARGE mill needed more generating capacity and a 500-kw. 220-volt, three-phase generator direct-connected to a Corliss engine, was at length purchased. The mill was operating on a two-phase system but we were assured that the new generator could be re-connected for two-phase and would operate satisfactorily, which it did up to about half load. Six months later the power demand increased and some trouble developed as the fields of the exciter and the generator heated to the danger point and we could not maintain the voltage at 180, much less at 230, its proper point.

Although some relief could have been obtained by improving the power factor it was decided to rewind the alternator with a two-phase winding. The large generator could not be idle for more than six days while it was being rewound. It was, therefore, necessary to plan the work so that the rewinding could be done with the least possible delay. The plant was idle on Sunday and so careful measurements were taken of the slots, wedges, and the existing winding. The machine was about 15 ft. in diameter and 3 ft. wide, with 360 open slots wound with diamond coils.

With this data, a new winding was designed having approximately 20 per cent more turns and by using flat wire instead of round it was found that the same cross-section of copper could be maintained. A wooden pattern was constructed representing twelve slots of the stator; then the coils were wound, dipped in insulating varnish, taped with oiled linen, sleeves put on the leads and the coils again taped with cotton tape and dipped. As the coils were finished they were placed on the wooden pattern and connected into groups of three, the number of coils per pole-phase-group. The slot insulation consisted of 0.015-in. fish-paper with a 0.030-in. strip in the bottom and between the coils. When the coils were finished all of the other material needed for the job was gotten together so that the work of rewinding could be started promptly on a Saturday noon.

As soon as the machine was shut down the stator was slid shaftways on its supporting base. The maximum travel allowed only about 3 in. between the ends of the stator coils and the field coils. Stripping of the old winding started at once and as it was a thirty-parallel, two-phase connection, the end of each branch was carefully unsoldered from the connecting coil so that it could be used again on all four main leads to the switchboard. After driving the wedges out, the coils came out easily, as the insulation was old and brittle. The slots were then cleaned carefully and new insulation put in. Three men were employed in rewinding, with a helper to carry the material to them. One man put in the coils in groups of three; as was previously mentioned they were connected in groups at the shop in order to speed up the work. The other man cut the fishpaper cells flush with the top of the slots and drove the wedges in. The wedges were of maple and were made in two pieces to be driven from each end of the slot. The lower tip of the wedge was slightly concave, as shown at *A* in the illustration, so that it would fold the fish-paper over as it was driven in. The wedges were easy to drive in on one side but it was difficult to drive them in on the other side on account of the fields being in the way, and the tool shown at *B* was designed. This tool was easily made of ¼-in. by 1-in. iron and was very efficient. The coils were all in and wedged by 12:00 o'clock that night.

Some devices used in rewinding large generator and method of phasing out.



Next morning we started connecting up. As previously stated, the four main leads with their thirty connecting branches were carefully saved from the old winding and as the new winding was started in the same relation as the old, the leads fitted perfectly and the work was speeded up considerably. One repair man made the connections with copper clips and the other soldered them. The pouring method was used. A plumbers' pot was filled with solder and with a ladle and the scoop shown at *C* it was possible to solder in close quarters and still do fast work. The helper taped all the connections.

After everything was finished the machine was given a spray coat of an oil-proof, air-drying insulating varnish. Inasmuch as we had taken the precaution of starting the new winding in the same relation as the old one, phasing out was hardly necessary but for safety it was decided to check up on it. This was done, as shown at *D*, with the generator switch open. Wire jumpers were placed on contacts 2 and 4 and these two wires run to separate phases of a small two-phase motor. The other free wires were first placed on upper contacts 1 and 3 and when the motor started the direction of rotation was noted. Then the two leads from the small motor were placed on lower contacts 1 and 3 and, as was expected, the direction of rotation was the same as before. The repair crew went home at 5 o'clock Monday morning, after the generator had been given a short test run to see that it operated satisfactorily. By carefully planning the work and doing beforehand everything that could be done in the shop the job went along smoothly and was completed in about 33 hours instead of the six days that had been allowed. In recognition of their good work the repair men were given an extra week's pay and two days to rest up in—and I will say that it was well worth it. ANTHONY J. MORRONI.
Denver, Colo.

Varnishes and Their Solvents

(Continued from page 126)

not have to be replaced by repeated thinning as often as is the case with the more volatile reducers.

Coal tar distillates such as F-160 are heavier than those derived from petroleum. They are more homogeneous and have a narrower cut. The solvent powers are the greatest of any of the materials described. They are not, as a rule, used alone but are mixed with petroleum distillates. By their use varnish bases that could not otherwise be used are put into solution. Only very small quantities, as a rule, need to be used. Varnishes containing them will be found to be extremely oilproof and extremely resistant to varnish solvents of all kinds. They should not, however, be used in the treatment of plain enameled wire coils, unless particular care is taken.

Turpentine is used to a very slight extent. Its solvent powers are great and hence the same objection to this product exists as is the case with the coal tar distillates.

Wood or denatured alcohol is used chiefly in shellac and quick drying finishing varnishes; that is, varnishes used over other coatings to give a glossy surface and, in some cases, for additional oilproofness. The big talking points for varnishes made with alcohol are the quickness with which they dry and the way in which they "set up" on the surface, and their appearance. They are not, however, insulators until thoroughly dry and they do not penetrate the interstices of the coils where insulation is most needed. They are brittle and have a tendency to crack, allowing moisture to enter the windings. They should only be used for outside protection of coils, for appearance and a hard surface.

Practical Points on Applying Varnish.—To insure uniformity of application you should assure yourself, first, that the varnish chosen is of uniform quality, and second, that the consistency at which you use it is always the same. The first should be guaranteed by your source of supply; the second must be regulated in your own shop. Furthermore, this consistency must be adjusted for the particular kind of work that is being performed. The varnish that is satisfactory for light coils is not at all adapted for heavy coils, nor for dipping armatures.

You should first thin the varnish to the point at which it works best on the particular kind of work at hand. Determine and record the specific gravity by means of a hydrometer, calibrated for liquids lighter than water, and thereafter see to it that the consistency does not vary. In other words, when the solvent evaporates, replace it. Remember, however, that the specific gravity is an indication of the consistency of a particular varnish only. It does not show a comparison between two different products. This is easy to understand because of the difference in gravity of the various types of solvents. Those already described range from 0.730 to over 0.800. Evidently the higher the gravity of the solvent the higher the gravity of the varnish, with like percentages of base.

Varnishes expand with a rise in temperature and contract as it lowers, just as other liquids do. This of course varies the specific gravity It has been found that readings of the hydrometer vary 0.0007 for each degree variation in temperature on the Centigrade scale. Hence if the normal gravity of a varnish is 0.870 at 21 deg. C. the hydrometer readings when the varnish is at 26 deg. C. will be 0.870 minus 0.0035 or 0.8665. Although apparently thinner, the varnish will still be of normal consistency. Similarly, if the temperature were 16 deg. C. the normal consistency would be 0.870 plus 0.0035, or 0.8735, although it would appear to be somewhat thicker.

In practice there is generally so little difference in temperature when the gravity is taken before work is done that no account need be taken of this variation. It is of interest only so far as the changes in consistency between summer and winter temperatures are concerned. However, if the varnish is to be used at a higher or lower temperature for a considerable period, the proper consistency of the varnish should be determined for the work at that particular temperature and thereafter carefully maintained. The variations of the normal gravity with temperature changes are shown in Table II.

Directions for Care of Varnishes.—Perhaps a few directions for the care of varnishes will not come amiss at this point. Keep the varnish tightly covered when not in use. Buy a hydrometer and use it. Determine the specific gravity at which the varnish works best for a particular job and take readings of the gravity every day before you start to use it. Add thinner when necessary to keep the varnish at the proper consistency. When thinning be sure that varnish and reducer are at the same temperature. Add the thinner slowly and stir it in thoroughly all the while. When cold thinner is added too rapidly it is liable to throw the varnish base out of solution. Large quantities, especially if put in too quickly, often

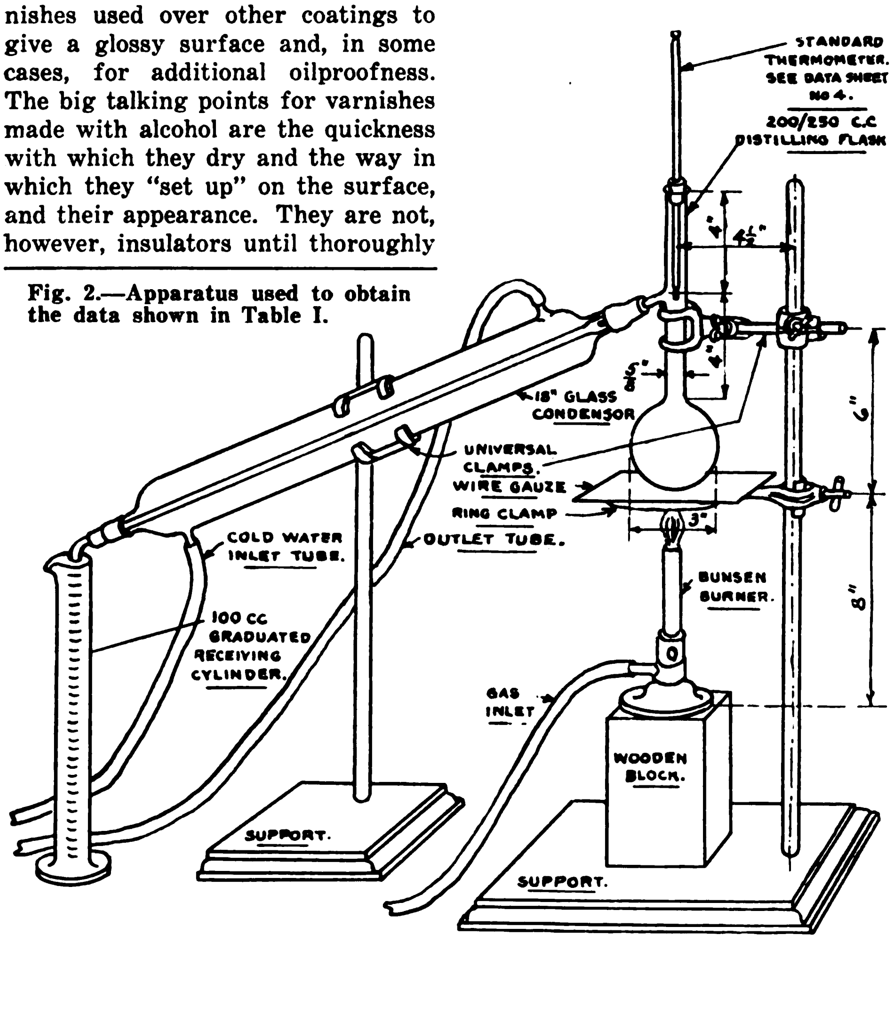


Fig. 2.—Apparatus used to obtain the data shown in Table I.

cause a like result. Warmth aids the union; hence it is better to have varnish and reducer at a temperature of between 70 deg. F. and 90 deg. F. After the thinner has been added, continue to stir until you are sure that it has all been properly mixed. This can be determined by the "feel," that is the way it runs off the paddle and the absence of streaks on the surface of the varnish. If the varnish gradually seems to change with successive thinnings, although the thinner mixes thoroughly, there is probably something wrong with the reducer and you should consult the manufacturer.

If the thinner, in spite of the utmost care, seems to liver or precipitate the varnish base it is quite likely that it does not have the necessary solvent powers. The addition of a small amount of a more powerful solvent will often remedy this.

There seems to be an impression among many men that repeated thinning destroys the good qualities of the varnish. This is not true. Remember that it is the base of the varnish that gives you the insulation. The base does not evaporate. You are simply replacing, in the process of thinning, thinner which has disappeared. A very interesting test is what we term the "shop test." This is made by filling a container with a varnish of a known specific gravity. Leave the container open day and night and each morning take a reading of the gravity and replace the solvent which has evaporated. A good varnish will remain in solution for at least 30 days without livering or curdling.

In conclusion we would point out that in purchasing varnish you are really paying for the base or useful material. The solvent does not provide any insulation and hence you should see to it that you are obtaining a varnish having a maximum amount of base. This can be determined by means of the same apparatus shown for determining the distillation range of the solvents, but when made in this way the test is a very delicate one and very difficult for anyone to perform without considerable experience. Probably the better way for the ordinary shopman to determine this would be by the number of coils that could be treated with the varnish, making sure that when he is comparing it with another material that he is getting the same coating on the outside and the same degree of penetration on the inside. At best this test gives only rough results. However, the varnish manufacturer should be willing to tell you what percentage of base his varnish contains and to supply you with a certificate from an independent laboratory, provided your purchases warrant it.

In line with other commodities you get in insulating varnish just what you pay for. Be sure that the product you are using is the proper one for your purpose; then when troubles arise take your source of supply into your confidence.

Table II.—Variations from normal gravity of varnishes with changes in temperature.

When a varnish is to be used for a considerable period at a higher or lower temperature than normal, the proper consistency for the work should be determined at that particular temperature and thereafter carefully maintained.

Degrees F.	Specific Gravities.															Degrees C.
32	.820	.825	.830	.835	.840	.845	.850	.855	.860	.865	.870	.875	.880	.885	.890	0.0
34	.819	.824	.829	.834	.839	.844	.849	.854	.859	.864	.869	.874	.879	.884	.889	1.1
36	.819	.824	.829	.834	.839	.844	.849	.854	.859	.864	.869	.874	.879	.884	.889	2.2
38	.818	.823	.828	.833	.838	.843	.848	.853	.858	.863	.868	.873	.878	.883	.888	3.3
40	.817	.822	.827	.832	.837	.842	.847	.852	.857	.862	.867	.872	.877	.882	.887	4.4
42	.816	.821	.826	.831	.836	.841	.846	.851	.856	.861	.866	.871	.876	.881	.886	5.5
44	.815	.820	.825	.830	.835	.840	.845	.850	.855	.860	.865	.870	.875	.880	.885	6.6
46	.815	.820	.825	.830	.835	.840	.845	.850	.855	.860	.865	.870	.875	.880	.885	7.7
48	.814	.819	.824	.829	.834	.839	.844	.849	.854	.859	.864	.869	.874	.879	.884	8.8
50	.813	.818	.823	.828	.833	.838	.843	.848	.853	.858	.863	.868	.873	.878	.883	10.0
52	.812	.817	.822	.827	.832	.837	.842	.847	.852	.857	.862	.867	.872	.877	.882	11.1
54	.811	.816	.821	.826	.831	.836	.841	.846	.851	.856	.861	.866	.871	.876	.881	12.2
56	.811	.816	.821	.826	.831	.836	.841	.846	.851	.856	.861	.866	.871	.876	.881	13.3
58	.810	.815	.820	.825	.830	.835	.840	.845	.850	.855	.860	.865	.870	.875	.880	14.4
60	.809	.814	.819	.824	.829	.834	.839	.844	.849	.854	.859	.864	.869	.874	.879	15.5
62	.808	.813	.818	.823	.828	.833	.838	.843	.848	.853	.858	.863	.868	.873	.878	16.6
64	.807	.812	.817	.822	.827	.832	.837	.842	.847	.852	.857	.862	.867	.872	.877	17.7
66	.807	.812	.817	.822	.827	.832	.837	.842	.847	.852	.857	.862	.867	.872	.877	18.9
68	.806	.811	.816	.821	.826	.831	.836	.841	.846	.851	.856	.861	.866	.871	.876	20.0
70	.805	.810	.815	.820	.825	.830	.835	.840	.845	.850	.855	.860	.865	.870	.875	21.1
72	.804	.809	.814	.819	.824	.829	.834	.839	.844	.849	.854	.859	.864	.869	.874	22.2
74	.803	.808	.813	.818	.823	.828	.833	.838	.843	.848	.853	.858	.863	.868	.873	23.3
76	.803	.808	.813	.818	.823	.828	.833	.838	.843	.848	.853	.858	.863	.868	.873	24.4
78	.802	.807	.812	.817	.822	.827	.832	.837	.842	.847	.852	.857	.862	.867	.872	25.5
80	.801	.806	.811	.816	.821	.826	.831	.836	.841	.846	.851	.856	.861	.866	.871	26.6
82	.800	.805	.810	.815	.820	.825	.830	.835	.840	.845	.850	.855	.860	.865	.870	27.7
84	.799	.804	.809	.814	.819	.824	.829	.834	.839	.844	.849	.854	.859	.864	.869	28.8
86	.799	.804	.809	.814	.819	.824	.829	.834	.839	.844	.849	.854	.859	.864	.869	30.0
88	.798	.803	.808	.813	.818	.823	.828	.833	.838	.843	.848	.853	.858	.863	.868	31.1
90	.797	.802	.807	.812	.817	.822	.827	.832	.837	.842	.847	.852	.857	.862	.867	32.2
92	.796	.801	.806	.811	.816	.821	.826	.831	.836	.841	.846	.851	.856	.861	.866	33.3
94	.795	.800	.805	.810	.815	.820	.825	.830	.835	.840	.845	.850	.855	.860	.865	34.4
96	.795	.800	.805	.810	.815	.820	.825	.830	.835	.840	.845	.850	.855	.860	.865	35.5
98	.794	.799	.804	.809	.814	.819	.824	.829	.834	.839	.844	.849	.854	.859	.864	36.6
100	.793	.798	.803	.808	.813	.818	.823	.828	.833	.838	.843	.848	.853	.858	.863	37.7
102	.792	.797	.802	.807	.812	.817	.822	.827	.832	.837	.842	.847	.852	.857	.862	38.8
104	.791	.796	.801	.806	.811	.816	.821	.826	.831	.836	.841	.846	.851	.856	.861	40.0
106	.791	.796	.801	.806	.811	.816	.821	.826	.831	.836	.841	.846	.851	.856	.861	41.1
108	.790	.795	.800	.805	.810	.815	.820	.825	.830	.835	.840	.845	.850	.855	.860	42.2
110	.789	.794	.799	.804	.809	.814	.819	.824	.829	.834	.839	.844	.849	.854	.859	43.3
112	.788	.793	.798	.803	.808	.813	.818	.823	.828	.833	.838	.843	.848	.853	.858	44.4
114	.787	.792	.797	.802	.807	.812	.817	.822	.827	.832	.837	.842	.847	.852	.857	45.5
116	.787	.792	.797	.802	.807	.812	.817	.822	.827	.832	.837	.842	.847	.852	.857	46.6
118	.786	.791	.796	.801	.806	.811	.816	.821	.826	.831	.836	.841	.846	.851	.856	47.7
120	.785	.790	.795	.800	.805	.810	.815	.820	.825	.830	.835	.840	.845	.850	.855	48.8
122	.784	.789	.794	.799	.804	.809	.814	.819	.824	.829	.834	.839	.844	.849	.854	50.0
124	.783	.788	.793	.798	.803	.808	.813	.818	.823	.828	.833	.838	.843	.848	.853	51.1
126	.783	.788	.793	.798	.803	.808	.813	.818	.823	.828	.833	.838	.843	.848	.853	52.2
128	.782	.787	.792	.797	.802	.807	.812	.817	.822	.827	.832	.837	.842	.847	.852	53.3
130	.781	.786	.791	.796	.801	.806	.811	.816	.821	.826	.831	.836	.841	.846	.851	54.4
132	.780	.785	.790	.795	.800	.805	.810	.815	.820	.825	.830	.835	.840	.845	.850	55.5
134	.779	.784	.789	.794	.799	.804	.809	.814	.819	.824	.829	.834	.839	.844	.849	56.6
136	.779	.784	.789	.794	.799	.804	.809	.814	.819	.824	.829	.834	.839	.844	.849	57.7
138	.778	.783	.788	.793	.798	.803	.808	.813	.818	.823	.828	.833	.838	.843	.848	58.8
140	.777	.782	.787	.792	.797	.802	.807	.812	.817	.822	.827	.832	.837	.842	.847	60.0
142	.776	.781	.786	.791	.796	.801	.806	.811	.816	.821	.826	.831	.836	.841	.846	61.1
144	.775	.780	.785	.790	.795	.800	.805	.810	.815	.820	.825	.830	.835	.840	.845	62.2
146	.775	.780	.785	.790	.795	.800	.805	.810	.815	.820	.825	.830	.835	.840	.845	63.3
148	.774	.779	.784	.789	.794	.799	.804	.809	.814	.819	.824	.829	.834	.839	.844	64.4

You Have a Part to Play in Safety Work

Here is a little jingle that carries a serious thought. It was written by G. H. McLaughlin, a crane man in Department 245 of Plant No. 1 of the Studebaker Corporation and appeared in that company's house organ, called "The Studebaker Cooperator."

A crane man's pathway is strewn with thorns,
With hardly a rose to relieve it;
Just to stand on the floor and look at him each morn
No person on earth would believe it.

He comes at your signal, glides along the steel path,
Though the consequence be what it may;
He takes up the slack and then hears the chain crack,
Slow music and flowers the next day.

Safety First signs are posted all over the shop,
And the men higher up really mean it.
But every darned bloke seems to think it a joke,
Or act like they never had seen it.

There may be other "rhyming bards" (unknown) among our readers. If so, we would like to hear from them now or any other time.

PRACTICAL PETE.

Voltage Changes on A. C. Motors

(Continued from page 137)

Or the number of turns per phase could be *decreased* in the desired percentage to get the effect of over-voltage. This can be carried up to the pull-out torque point of the motor, but for good results stop within 20 per cent of the pull-out torque.

The per cent change in these factors varies in different machines; hence we cannot say that a 10 per cent change in voltage of any machine will have a certain per cent change in each of the factors. It is obvious that the greater the per cent over-voltage impressed on the motor, the more the afore-mentioned factors will affect its operation.

With under-voltage the efficiency is lower, the iron losses are reduced, the secondary and primary copper losses are greater, and the power factor is slightly raised. With 10 per cent under-voltage the design of the motor would determine whether the full rated power could be delivered without overheating. With a 25 per cent reduction in voltage the horsepower rating would have to be reduced at least one-third.

The fact that the starting torque of an induction motor varies as the square of the applied line voltage makes it possible to determine the resulting starting torque at any voltage, or the required line voltage for a given starting torque. The following formulas can be used for setting auto-starters. Let: *T* equal torque at full line voltage; T_2 equal torque at reduced line voltage; *V* equal full line voltage; V_2 equal reduced line voltage.

Then, $T : V^2 = T_2 : V_2^2$ or $T_2 = TV_2^2 \div V^2$ and $V_2 = V\,[\sqrt{(T_2 \div T)}]$.

When the full-load torque of any motor is known, the voltage required for any lower torque value can be found. Assume a 220-volt motor which will start with 2.5 times full-load torque with full line voltage. For a certain drive only 75 per cent of full-load torque is needed at starting. What voltage is required?

Substituting in the above formula, $V_2 = 220\,[\sqrt{(.75 \div 2.5)}]$ equals 120.34 volts. This is 45.5 per cent of full voltage. Then if the lowest tap on the starter coil is 60 per cent the starting torque will be $T_2 = T\,(132^2 \div 220^2) = .90\,T$, or 90 per cent of full-load torque.

If the full-load torque is known the torque at any voltage lower than the full-line voltage will be less according to approximately the square of the voltage, provided the change is not too great. For example, suppose the line voltage of a 440-volt motor dropped to 400 volts. The torque will be $400^2 \div 440^2$ equals 0.826, times the original torque. Or a reduction of 9.1 per cent in voltage resulted in 17 per cent less torque.

This is only approximately correct because the increased slip and other factors have not been taken into account. It is sufficiently accurate, however, for rough calculations where the voltage change is not too great. If the torque on the motor remains the same after this voltage drop, more current will be drawn from the line. This increased current might overheat the motor or, if the load were heavy enough, the motor would stop running.

When a motor is working on over-voltage and it is desired to keep the magnetic conditions, etc., the same, the turns per phase must be increased in the same percentage as the over-voltage. Likewise for under-voltage the turns per phase or coil must be decreased.

Table VIII—Sin Values for 45 to 90 Degrees for Use in Figuring Chord Factors

Deg.	°0 .0	°0 .1	°0 .2	°0 .3	°0 .4	°0 .5	°0 .6	°0 .7	°0 .8	°0 .9
45	0 .7071	0 .7083	0 .7096	0 .7108	0 .7120	0 .7133	0 .7145	0 .7157	0 .7169	0 .7181
46	0 .7193	0 .7206	0 .7218	0 .7230	0 .7242	0 .7254	0 .7266	0 .7278	0 .7290	0 .7302
47	0 .7314	0 .7325	0 .7337	0 .7349	0 .7361	0 .7373	0 .7385	0 .7396	0 .7408	0 .7420
48	0 .7431	0 .7443	0 .7455	0 .7466	0 .7478	0 .7490	0 .7501	0 .7513	0 .7524	0 .7536
49	0 .7547	0 .7559	0 .7570	0 .7581	0 .7593	0 .7604	0 .7615	0 .7627	0 .7638	0 .7649
50°	0 .7660	0 .7672	0 .7683	0 .7694	0 .7705	0 .7716	9 .7727	0 .7738	0 .7749	0 .7760
51	0 .7771	0 .7782	0 .7793	0 .7804	0 .7815	0 .7826	0 .7837	0 .7848	0 .7859	0 .7869
52	0 .7880	0 .7891	0 .7902	0 .7912	0 .7923	0 .7934	0 .7944	0 .7955	0 .7965	0 .7976
53	0 .7986	C .7997	0 .8007	0 .8018	0 .8028	0 .8039	0 .8049	0 .8059	0 .8070	0 .8080
54	0 .8090	0 .8100	0 .8111	0 .8121	0 .8131	0 .8141	0 .8151	0 .8161	0 .8171	0 .8181
55	0 .8192	0 .8202	0 .8211	0 .8221	0 .8231	0 .8241	0 .8251	0 .8261	0 .8271	0 .8281
56	0 .8290	0 .8300	0 .8310	0 .8320	0 .8329	0 .8339	0 .8348	0 .8358	0 .8368	0 .8377
57	0 .8387	0 .8396	0 .8406	0 .8415	0 .8425	0 .8434	0 .8443	0 .8453	0 .8462	0 .8471
58	0 .8480	0 .8490	0 .8499	0 .8508	0 .8517	0 .8526	0 .8536	0 .8545	0 .8554	0 .8563
59	0 .8572	0 .8581	0 .8590	0 .8599	0 .8607	0 .8616	0 .8625	0 .8634	0 .8643	0 .8652
60°	0 .8660	0 .8669	0 .8678	0 .8686	0 .8695	0 .8704	0 .8712	0 .8721	0 .8729	0 .8738
61	0 .8746	0 .8755	0 .8763	0 .8771	0 .8780	0 .8788	0 .8796	0 .8805	0 .8813	0 .8821
62	0 .8829	0 .8838	0 .8846	0 .8854	0 .8862	0 .8870	0 .8878	0 .8886	0 .8894	0 .8902
63	0 .8910	0 .8918	0 .8926	0 .8934	0 .8942	0 .8949	0 .8957	0 .8965	0 .8973	0 .8980
64	0 .8988	0 .8996	0 .9003	0 .9011	0 .9018	0 .9026	0 .9033	0 .9041	0 .9048	0 .9056
65	0 .9063	0 .9070	0 .9078	0 .9085	0 .9092	0 .9100	0 .9107	0 .9114	0 .9121	0 .9128
66	0 .9135	0 .9143	0 .9150	0 .9157	0 .9164	0 .9171	0 .9178	0 .9184	0 .9191	0 .9198
67	0 .9205	0 .9212	0 .9219	0 .9225	0 .9232	0 .9239	0 .9245	0 .9252	0 .9259	0 .9265
68	0 .9272	0 .9278	0 .9285	0 .9291	0 .9298	0 .9304	0 .9311	0 .9317	0 .9323	0 .9330
69	0 .9336	0 .9342	0 .9348	0 .9354	0 .9361	0 .9367	0 .9373	0 .9379	0 .9385	0 .9391
70°	0 .9397	0 .9403	0 .9409	0 .9415	0 .9421	0 .9426	0 .9432	0 .9438	0 .9444	0 .9449
71	0 .9455	0 .9461	0 .9466	0 .9472	0 .9478	0 .9483	0 .9489	0 .9494	0 .9500	9 .9505
72	0 .9511	0 .9516	0 .9521	0 .9527	0 .9532	0 .9537	0 .9542	0 .9548	0 .9553	0 .9558
73	0 .9563	0 .9568	0 .9573	0 .9578	0 .9583	0 .9588	0 .9593	0 .9598	0 .9603	0 .9608
74	0 .9613	0 .9617	0 .9622	0 .9627	0 .9632	0 .9636	0 .9641	0 .9646	0 .9650	0 .9655
75	0 .9659	0 .9664	0 .9668	0 .9673	0 .9677	0 .9681	0 .9686	0 .9690	0 .9694	0 .9699
76	0 .9703	0 .9707	0 .9711	0 .9715	0 .9720	0 .9724	0 .9728	0 .9732	0 .9736	0 .9740
77	0 .9744	0 .9748	0 .9751	0 .9755	0 .9759	0 .9763	0 .9767	0 .9770	0 .9774	0 .9778
78	0 .9781	0 .9785	0 .9789	0 .9792	0 .9796	0 .9799	0 .9803	0 .9806	0 .9810	0 .9813
79	0 .9816	0 .9820	0 .9823	0 .9826	0 .9829	0 .9833	0 .9836	0 .9839	0 .9842	0 .9845
80°	0 .9848	0 .9851	0 .9854	0 .9857	0 .9860	0 .9863	0 .9866	0 .9869	0 .9871	0 .9874
81	0 .9877	0 .9880	0 .9882	0 .9885	0 .9888	0 .9890	0 .9893	0 .9895	0 .9898	0 .9900
82	0 .9903	0 .9905	0 .9907	0 .9910	0 .9912	0 .9914	0 .9917	0 .9919	0 .9921	0 .9923
83	0 .9925	0 .9928	0 .9930	0 .9932	0 .9934	0 .9936	0 .9938	0 .9940	0 .9942	0 .9943
84	0 .9945	0 .9947	0 .9949	0 .9951	0 .9952	0 .9954	0 .9956	0 .9957	0 .9959	0 .9960
85	0 .9962	0 .9963	0 .9965	0 .9966	0 .9968	0 .9969	0 .9971	0 .9972	0 .9973	0 .9974
86	0 .9976	0 .9977	0 .9978	0 .9979	0 .9980	0 .9981	0 .9982	0 .9983	0 .9984	0 .9985
87	0 .9986	0 .9987	0 .9988	0 .9989	0 .9990	0 .9990	0 .9991	0 .9992	0 .9993	0 .9993
88	0 .9994	0 .9995	0 .9995	0 .9996	0 .9996	0 .9997	0 .9997	0 .9997	0 .9998	0 .9998
89	0 .9998	0 .9999	0 .9999	0 .9999	0 .9999	1 .000	1 .000	1 .000	1 .000	1 .0C0

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

The Truscon Laboratories, Detroit, Mich.—An interesting "Maintenance Chart" shows by a cross-section diagram of a building where the various Truscon maintenance products may be used in an industrial plant. These products include special preparations for walls, floors, ceilings and practically any application or treatment for steel or cement surfaces, and a special skylight and window cleaner.

Esterline-Angus Company, Indianapolis, Ind.—Bulletin 124 entitled "A Complete New Line of Graphic Instruments" announces the new model LR Esterline-Angus graphic meters which are made in wall type, switchboard type and portable type cases. They are also made with five hourly chart speeds which may be obtained by changing gears on the outside of the clock case. These speeds are ¾-in., 1½-in., 6-in. and 12-in. per hour. The construction and other features of the instruments are explained in the bulletin.

The Wireless Resistor Company of America, 1023-29 Coldspring Avenue, Milwaukee, Wis.—A booklet entitled "The Story of the Globar Element" describes the construction, characteristics and use of "Globar" which is a non-metallic electrical heating unit for industrial and domestic uses. This is claimed to be able to operate continuously up to 2,400 deg. F., and at higher temperatures for short periods. A number of industrial and domestic applications are described.

Diehl Manufacturing Company, Elizabeth, N. J.—Circular 1012 D-125 contains a brief description of the various types of Diehl motors, together with a condensed price list of the standard apparatus most frequently called for.

The Hayward Company, 50 Church Street, New York City—Pamphlet 620 entitled "Hayward Automatic Take-Up Reels" describes this special automatic take-up reel for use on electric motor-buckets and electromagnets in connection with locomotive and traveling cranes.

Mathias Klein and Sons, 3200 Belmont Avenue, Chicago, Ill.—Catalog 19 describes the line of Klein tools for electricians, linemen and mechanics.

American Schaeffer and Budenberg Corporation, Brooklyn, N. Y.—A 28-page catalog, No. 1400, describes the "American" spring pop safety and relief valve for stationary, portable and marine use.

The Humphreys Manufacturing Company, Mansfield, Ohio.—Bulletin 272 describes the points in the construction and operation of the Humphreys power pumps for miscellaneous industrial purposes. These are built for motor or gas engine drive.

The Phister Manufacturing Company, 717 Sycamore Street, Cincinnati, Ohio —A leaflet describes the Phister extinguisher, a 1-gal. carbon tetrachloride machine which is automatic in action. This extinguisher consists of a top and bottom casting of heavy brass to which is fastened an inner and outer brass shell forming two chambers. The outer chamber contains carbon tetrachloride and the inner chamber contains air under pressure, which when released into the outer chamber forces the liquids in a continuous stream a distance of 35 to 40 ft. through the discharge hose. Carbon tetrachloride is a non-conducting and non-freezing liquid which can be used on electrical fires.

Blue Seal Iron Company of Ohio, 554-55 Leader-News Building, Cleveland, Ohio—A small circular describes the use of Blue Seal Iron for making permanent patches and repairs. For example, the electrician can use it for repairing castings, motor frames, commutator ends, electrical fixtures, for electrical "ground work" and when joining wires which require more strength than is obtainable from ordinary solder.

Smith and Serrell, Central Avenue at Halsey Street, Newark, N. J.—A bulletin describes the "Keytite" self-fitting key. This is a special key made with a hardened steel cutting edge near the end to cut its fit into the keyway as it is driven in by a hammer. These keys are made with or without heads.

Grinnell Company, Providence, R. I.—An 82-page booklet on "Grinnell" adjustable pipe hangers gives description, dimensions and specifications of various pipe hangers and their applications. Several pages are devoted to instructions and information in regard to installing.

The Black and Decker Manufacturing Company, Towson Heights, Baltimore, Md. — An interesting catalog covers the Black and Decker portable electric tools and other shop equipment including electric drills, valve grinders, screwdrivers, electric bench and pedestal grinders, and electric air compressors. Phantom views show the construction and operation of the portable electric drill and other equipment.

Gillis and Geoghegan, 558 West Broadway, New York City—A new 24-page, two-color catalog illustrates actual installations of "G & G" telescopic hoists as used for handling ash cans, barrels, bales and other loads between floors.

Herbert Morris, Inc., Buffalo, N. Y.—Booklet 5041, entitled "Morris Machines to Lift and Shift," lists a wide variety of chain-blocks and illustrates some of their numerous applications.

Electric Furnace Construction Company, 1015 Chestnut Street, Philadelphia, Pa.—A folder describes the Soderberg Self-Baking Continuous Electrode adapted for stationary and tilting electric furnaces. In making these a raw mixture of carbonaceous material is tamped into a ribbed cylinder of light gage metal to form the electrode. As the electrode is consumed in stationary furnaces it is lowered into the furnace and new electrode casings added to the top. With tilting furnaces the electrode is removed and another inserted while the first is built up. A claim is made for saving in electrode cost and an increase in running time due to freedom from idleness while changing.

The North Electric Manufacturing Company, Galion, Ohio—A 16-page booklet describes the North Private Automatic Exchange for providing interior communication in factories, mills, railroad offices and shops, business houses and wherever instantaneous and accurate communication is needed. In addition to telephone service this system will provide for a conference arrangement, code-call system for locating executives, watchman service for the protection of the offices and plant, fire alarm system, warning of danger or emergency, annunciator service and pick-up service, which allows a call on one telephone to be answered on another in the absence of the called party.

The E. F. Hauserman Company, 1729 East Twenty-second Street, Cleveland, Ohio—A series of leaflets describe the Hauserman system of partitions, shelving and skylights. The partitions are designed particularly for foremen's offices and other small inclosures. The steel shelvings are available in a variety of shelves and pigeonholes, drawers and bins.

Wright-Hibbard Industrial Truck Company, Inc., Phelps, N. Y.—A folder describes the Wright-Hibbard type of elevating platform trucks. Some of the advantages claimed for this electric truck are a short turning radius, light weight and simplicity.

The Jeannin Electric Company, Toledo, Ohio—A 36-page booklet covers the construction, use and application of the Jeannin single-phase, repulsion-induction motors. Of particular interest is the short-circuiting device which operates when the motor is at rest or below normal speed.

Thermalene Gas Corporation, Kankakee, Ill.—A circular describes the Thermalene ideal goggles for use in welding. These are adjustable and so fixed that the lens may be turned up when not welding without removing the goggles.

Holophane Glass Company, Inc., 42 Madison Avenue, New York City—Booklet 375, entitled "Holophane Datalog" presents a large amount of data on illumination as compiled by the engineering department of this company from numerous investigations and study. A table gives the desirable illumination which should be provided for various locations in good modern lighting practice. Other topics discussed are: depreciation factor and maintenance; how to plan an installation; coefficient of utilization for each of the various types of reflectors manufactured by this com-

pany; a description of each reflector with various installation and engineering information concerning it; reflection factors of walls and ceilings; a description of the Holophane lightmeter, with special recommendations for its use.

Steel City Electric Company, Pittsburgh, Pa.—Catalog 34 is a complete catalog and price list of the various conduit fittings and boxes and other electrical supplies manufactured by this company and distributed through jobbers.

The Ohio Valley Pulley Works, Maysville, Ky.—A folder gives dimensions and prices for "Limestone" motor pulleys for motors, dynamos and similar work. This is a wood pulley built upon an iron hub.

W. T. Hunsdorf and Company, 720 Frankfort Avenue, Cleveland, Ohio.—Small circulars describe the high speed "Pin-Coil Winder" which is claimed to have quick adjustment and to be easily operated in the winding of pin-wound coils. This winder is equipped with turn counter and multiple wire grip. Another folder describes the coil duplicating machine which is used for converting pin-wound coils into high-grade "knuckle-type" coils for armature or stator work.

Hasler-Tel Company, 461 Eighth Street, New York City—Folders describe the "Hasler Speed Indicators." These speed indicators are provided with three pointers, one for centered shafts, another for uncentered shafts and a third with a small wheel which is used to measure the circumferential or linear speed. The first two are used to obtain r.p.m. and the third in measuring surface speed in feet per minute as on beds of machines or material in lathes.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis.—Publication 3062 entitled "Electric Conduction Heaters," describes and illustrates the application of electric heat on metal pots, metal molds, embossing press heads, gluing machines, package sealing machines, thread finishing machines, shoe and textile machines, celluloid dies and other general industrial and machine applications. Various types of heater construction are discussed, with the possibilities of applying electric heat to many industrial processes.

Foamite-Childs Corporation, Utica, N. Y.—Folders describe the Foamite equipment for smothering stubborn fires in oil, gasoline, paint- and varnish-dipping tanks, quenching tanks, and the like.

The L. S. Starrett Company, Athol, Mass.—A revised supplement to Starrett Catalog 22 on "New Starrett Tools" lists additional special machinists tools and is issued supplementary to the general catalog.

The Schatz Manufacturing Company, Poughkeepsie, N. Y.—Catalog 8 lists the "Commercial" annular ball bearing rollers of both regular and special types. These balls are not ground and are intended for a wide variety of uses under moderate speed and light duty. Some of the industrial uses are on gravity roll conveyors, trucks, grindstones, sliding doors, belt conveyor rolls, casters, and a wide variety of machines.

Reliance Electric and Engineering Company, Cleveland, Ohio—Bulletin 2014 describes the Type T Reliance motors for direct current. In addition to a general discussion on why a more rugged, general-service motor is required, a number of illustrations is given of each of the types of motors and also of each separate part. Additional illustrations give the method of assembling. The largest of these motors are made with split frames if desired. A large number of installations on a variety of applications are included.

W. A. Jones Foundry and Machine Company, 4401-51 West Roosevelt Road, Chicago, Ill.—Catalog 27 contains much valuable information on cast-iron, steel, wood and paper pulleys, such as the weights and extra lists for special types and rubber coverings. It also describes, illustrates and lists "Lemley" ball bearing loose pulleys and ring-oiling loose pulleys.

C. J. Tagliabue Manufacturing Company, 18-88 Thirty-Third Street, Brooklyn, N. Y.—A folder describes the "Tag" shutoff valve which is connected in the fuel lines of oil burners and other similar devices to automatically cut off the oil flow the instant that the steam or air pressure used for atomizing falls below the required minimum.

The Johns-Pratt Company, Hartford, Conn.—A special folder shows the construction of the "Noark" universal service switch. This uses plug fuses which may be removed without opening the switch.

The Thermal Syndicate, Ltd., 350 Madison Avenue, New York City—A booklet entitled "Vitreosil Data" describes the electrical insulating value and use of "Vitreosil", which is a fused quartz or silica, as well as its other applications in laboratory and chemical work.

Acheson Graphite Company, Niagara Falls, N. Y.—A small folder describes the Acheson welding electrodes for graphite arc electric welding and cutting and gives sizes and prices. A page is devoted to Acheson graphite plates for use in backing up welds.

Westinghouse Electric & Manufacturing Company. Pittsburgh, Pa.—A 24-page booklet entitled, "A Material of Endless Possibilities," contains information about "Micarta" and the many uses to which it has been put and the possibilities of some other applications.

Century Electric Company, St. Louis, Mo.—Form 366 is a small booklet describing the Century squirrel-cage-induction polyphase motors and some of their various applications.

Burke Electric Company, Erie, Pa.—Bulletin 128 describes the types of polyphase induction motors, gives the details of construction and also illustrates a number of their industrial applications.

Ward Leonard Electric Company, Mount Vernon, N. Y.—Bulletin 57 describes the Vitrohm speed regulator of the fully-enclosed type which is designed for use with all types of constant-torque, direct-current motors up to ⅓ hp., 115 or 230 volts, and with variable-torque motors up to ½ hp. rating.

Hauck Manufacturing Company, 114 Tenth Street, Brooklyn, N. Y.—Catalog 100, "Hauck Oil Burning Appliances" shows a wide variety of applications of this equipment in boiler shops, for brazing in coppersmith and pipe shops, in foundries, for furnaces and forges, in machine and repair shops for straightening, heating, brazing and pre-heating for welding, for removing disks, gears or pulleys from shafts by expanding hub, for thawing and for many other industrial applications in factories, foundries, railroad shops, machine and repair shops, shipyards and docks. Bulletin 112 gives special applications of the Hauck burner for foundries, boiler, machine and repair shops.

North Western Expanded Metal Company, Old Colony Building, Chicago, Ill.—A 16-page booklet entitled "Practical Machine Guards" shows how these may be constructed from "Econo" expanded metal by fastening the corners and edges together with angle iron, flat strips, or U-edging. The expanded metal comes in sheets and can be cut to fit the specific requirements of the guard.

The Robbins and Myers Company, Springfield, Ohio—Bulletin 137 describes the construction, operating characteristics, and gives general information, including the ratings and dimension sheets for the R. & M. types "R" and "RA" repulsion-induction motors. These are specially suitable for driving devices such as pumps, compressors, shoe-repairing machines and all other apparatus requiring high starting torque with low starting current.

The Goodyear Tire and Rubber Company, Inc., Akron, Ohio.—A 64-page "Handbook of Conveyor and Elevator Belting" is a handbook well worth being in the hands of every industrial engineer having to do with conveyor or elevator belts. Because of the variety of conditions and requirements, these are handled separately. Such subjects as capacity, width, weight per foot of belt, tension in belt, power required, number of plies required, take-up and counter-weights, idlers, belt joints, service records, and how Goodyear rubber conveyor belts and elevator belts are made, in addition other interesting data are included.

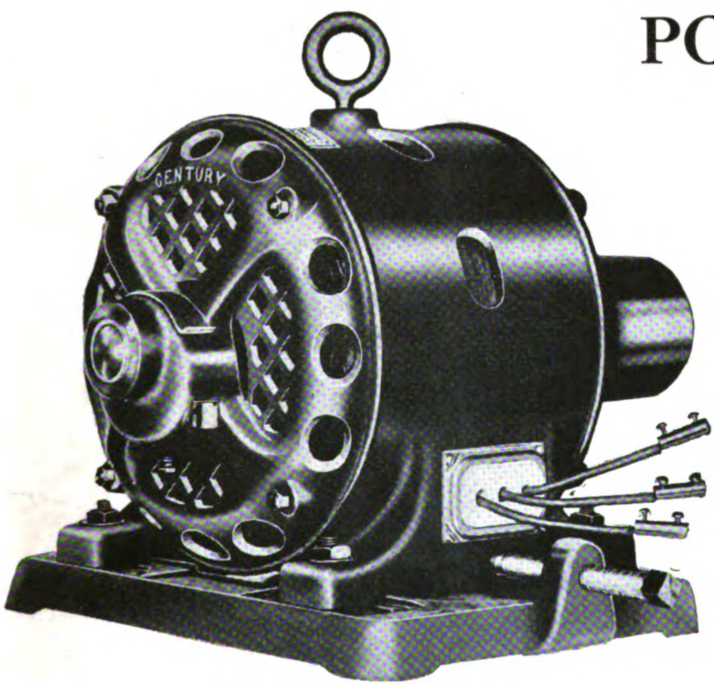
The Fuerst-Friedman Company, 1251 West Third Street, Cleveland, Ohio—No. 2 of a series of "Motor Instructions and Trouble Locator" cards which may be hung up in the shop, is entitled "Proper Fusing" and gives a table showing the ampere rating and sizes of running and starting fuses for three-phase, alternating-current motors, 220, 440, 550, and 2,200 volts, from ¼ to 500 hp. No. 1 of the series took up some of the important points to consider in the installation of motors.

The Hartford Steam Boiler Inspection and Insurance Company, Hartford, Conn.—A folder entitled "Insurance of Electrical Machinery" describes the advantages of protection against loss arising from the breakdown of electrical machinery. This folder tells what the insurance is and what it will cover.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of
Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review | APRIL, 1924 | McGraw-Hill Co., Inc Chicago. Ill.



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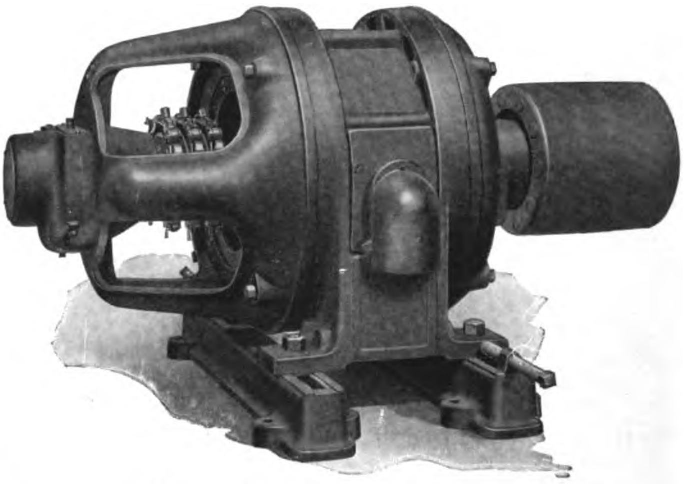
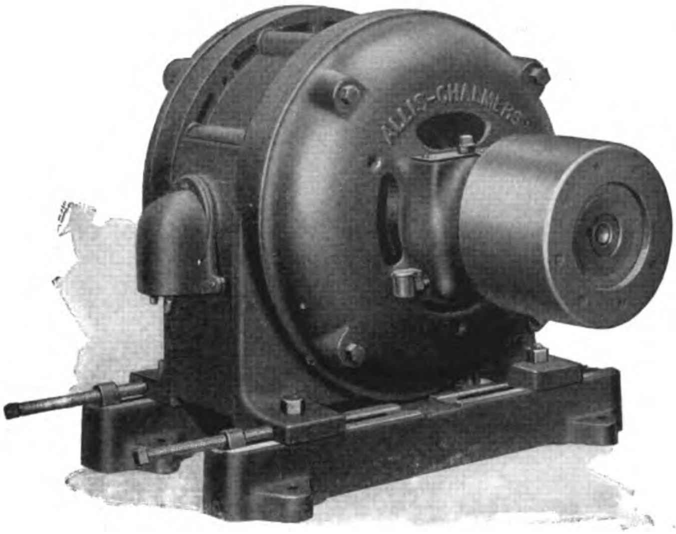


Type "ARY" Slip Ring Motor



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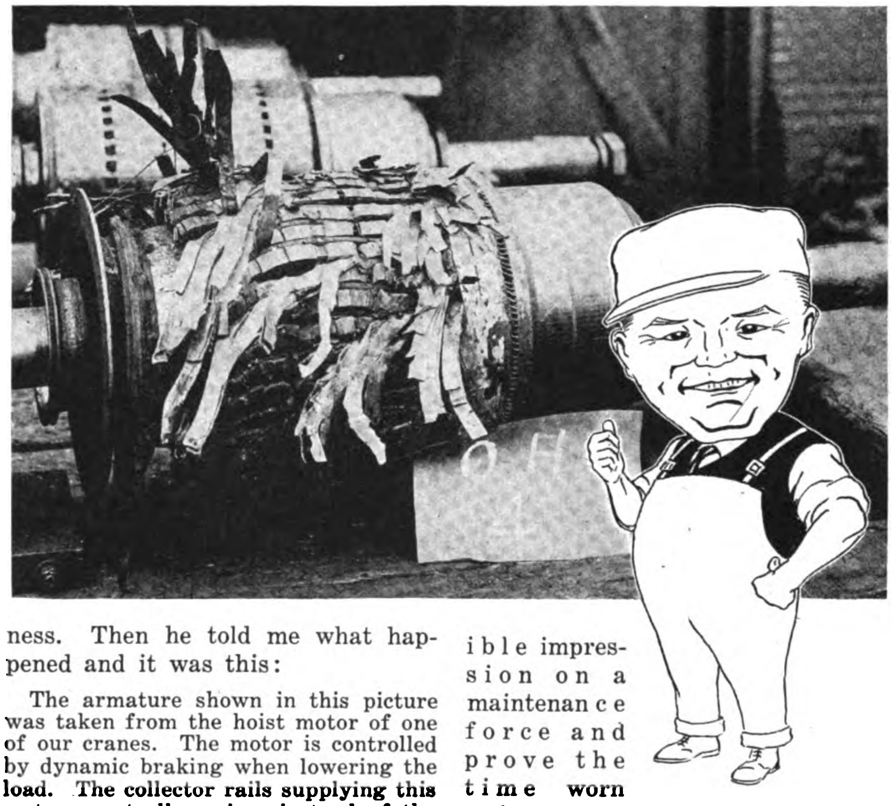
INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 82 Chicago, April, 1924 *Number 4*

Here's What May Happen When You Get Careless

In Inspections and Adjustments of Control Devices and Ignore Precautions Against Natural Wear and Tear



I HAVE just returned from a trip through some large industrial works where I always feel at home with the hum of machines all around and have a chance to chat with men who talk about their work with an intimate knowledge of it and the pride of doing something of interest to a visitor who used to be one of them. Of the things I saw and the things I was told there will be more later in articles soon to appear, for every man I visited had a method or a practical scheme that represents hours of thought and has cured some particular trouble-making condition.

But in one plant I saw this picture of an exploded armature that shows as nothing else can the thorns that prick the pride of the superintendent who works nights and days to prevent such troubles and is always urging his men to follow the precautions of inspection and maintenance that will eliminate them. At first he did not want me to take the picture away, but I convinced him that it was no reflection on him that this one accident had occurred over a long period of time and that it would enable me to call the attention of others to the fruits of carelessness. Then he told me what happened and it was this:

> The armature shown in this picture was taken from the hoist motor of one of our cranes. The motor is controlled by dynamic braking when lowering the load. The collector rails supplying this motor are trolley wires instead of the more modern angle-iron or bar-type collector rails. At the time this armature failed, the motor was lowering a very heavy load. Just when the hook speed became normal one of the trolley wires in the dynamic circuit broke and the armature ran away. The shoe brake should have prevented the runaway, but it was adjusted so loosely that it was ineffective.

In this particular plant inspection requirements are rigidly outlined and every man knows that failure to follow them calls for immediate dismissal. But in this case the inspector became careless and took one of those chances that are never safe to men or machines. The blame was easily placed and the prevention so simple with thorough inspection and proper adjustments that the same accident will not happen again unless similar carelessness and indifference to inspection requirements creep in. And this is hardly probable for a long time, as the actual results of an accident like this leave an indelible impression on a maintenance force and prove the time worn saying about an ounce of prevention and the pound of cure.

Let me say then to you men in charge of inspection—Follow the instructions of your boss and discuss them afterwards. Remember that he cannot do his job and yours, too, and that you owe it to yourself, your family and the company that pays your salary to be as careful, thorough and persistent in preventing troubles as you are in correcting them. Some day when you are the boss you will expect this of your men and the best way that I know to prove that you have the ability for a better job is to help your present boss to prevent accidents, avoid breakdowns and make improvements which will save the trouble and money that he knows and you know will result.

Practical Pete

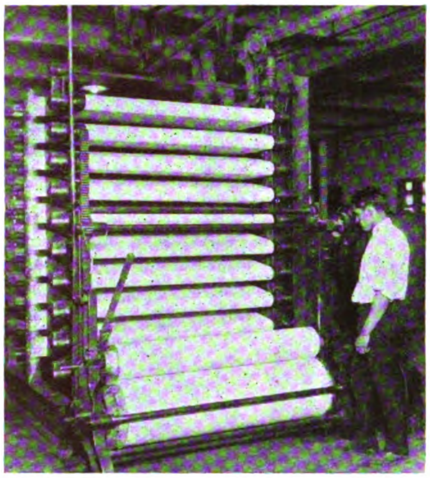
A Glimpse Into

The Goodyear Tire and Rubber Company

Where 32,000 rubber tires, 37,000 tubes and 300,000 pairs of rubber heels, in addition to large quantities of rubber belting, hose, packing and many other rubber products, are produced daily in their extensive plants.

LAST YEAR at the Akron, Ohio, plant of the Goodyear Tire and Rubber Company 12,000,000 kilowatt-hours of electrical energy were generated and used in the manufacture of numerous rubber products. In addition, the Los Angeles, Calif., plant used about 10,000 horsepower and the Canadian plant 5,000 horsepower daily. The milling of the rubber in the processing of the crude material to the compounded form which is used in manufacturing requires the largest amount of power of any other operation in this industry.

The manufacturing plants of the Goodyear Tire and Rubber Company have a total floor space of 7,250,000 sq. ft., or 166 acres. If this were laid out on one floor it would be over one-fourth of a mile square. This company started production in 1898 and by the year 1902 had reached an output of 5,000 tires per year. Last year, it produced 9,250,000 tires and up to date, has produced over 60,000,000 tires. In addition, in 1923 the Goodyear Tire and Rubber Company placed on the market 81,000,000 pairs of rubber heels, which is more than enough to equip the shoes of each adult in this country with a pair of heels. Also, it produced 8,000,000 ft. of belting, 25,000,000 ft. of hose and over 2,500,000 lb. of packing and similar products, not including molded goods. This list, however, does not include all the rubber products produced.



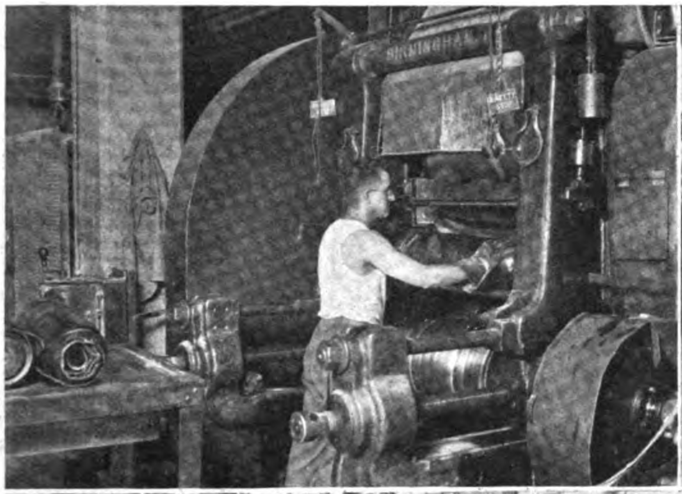
Before use the fabric must be perfectly dry.

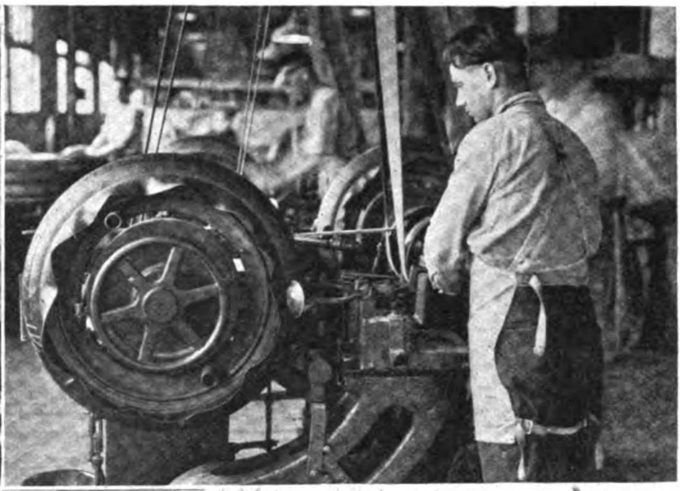
As the fabric passes over the heated rolls it is thoroughly dried. The rubber industry uses altogether about 450,000 bales of cotton each year, of which the Goodyear Company alone uses about 75,000 bales.

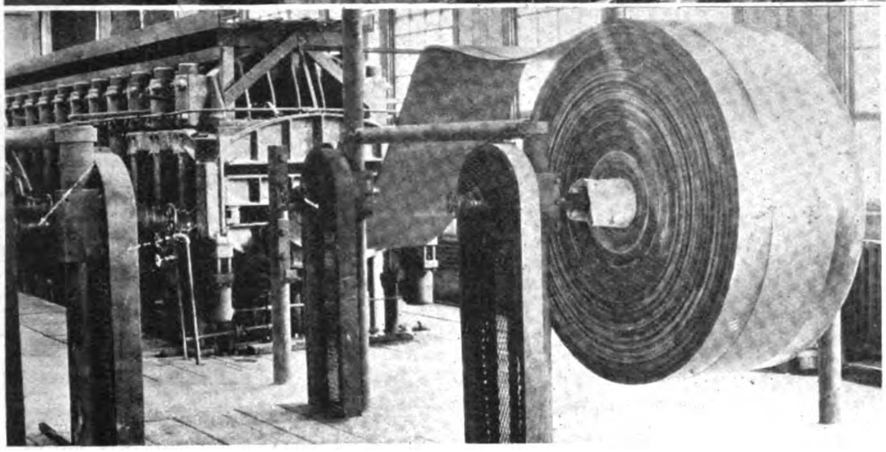
The rubber industry and its growth is closely related to the rapid growth of the automobile industry. The increased demand for automobile tires has been one of the largest factors in the growth of this industry. Crude rubber is practically all imported from South America, Ceylon, Borneo and the Malay Peninsula. It is made from a milk or gum obtained from a tree. In 1923, about 305,000 tons of crude rubber, or 80 per cent of the entire world's consumption were used in the United

Plant No. 1 at Akron, Ohio, and the Goodyear Cotton Mills at Goodyear, Conn.

The Goodyear Tire and Rubber Company, not only has its own factories but also has its own cotton mills in Connecticut and cotton plantations in Arizona. The payroll of this company was over $30,000,000 in 1923. The total output in 1923 of all the Goodyear plants was 237,000,000 lb. of rubber products.







Three operations in the manufacture of rubber products.

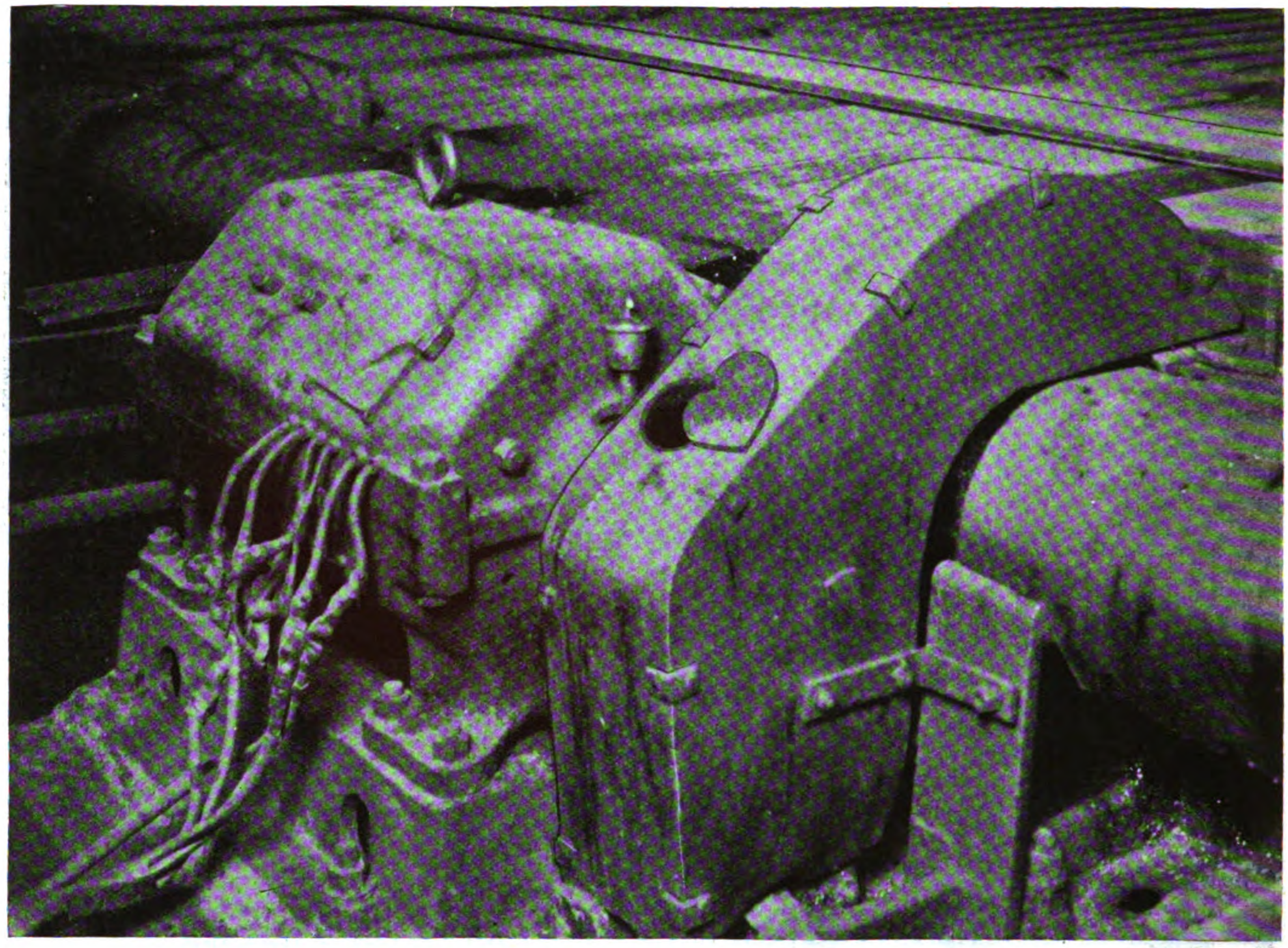
In the milling of rubber (upper left illustration) a large amount of power is consumed as the rubber is worked under powerful rolls under high pressure. Notice the safety stop or trip by which the operator can, by grasping it with either hand, stop the machine instantly. In the manufacture of rubber tires (above) much of the work is done by machines. This has resulted not only in increased production per man, but in better tires. The illustration at the left shows one of the large presses used in the manufacture of rubber belting. Last year, 8,000,000 ft. of belting were made by this company.

The two main factories of the Goodyear Tire and Rubber Company at Akron, Ohio.

Factory No. 2, in the foreground, and No. 1 in the distance (also shown on the opposite page), are the two main factories of the Goodyear Tire and Rubber Company. In addition, other large factories are located in Los Angeles, Calif., and at Bowmanville, Ont. In the two plants shown below the machines and equipment are driven by 2,600 electric motors with a total rating of 74,157 hp., and ranging from ½- to 750-hp. rating each.

States. Of this, Goodyear consumed about 50,000 tons. In addition to the rubber large quantities of cotton are also used to form a base on which to deposit the rubber, as in tires, hose and belting. The total consumption of cotton by the rubber industries in 1923 was 450,000 bales of which Goodyear used 75,000 bales.

During the past ten years, this industry has grown to be one of the largest in *(Continued on page 210)*



The armature shaft of this motor runs on roller bearings.

The motor drives one of the runout tables of a skelp mill. As will be noticed the table rollers are driven through bevel gears from a lineshaft, the lineshaft in turn being driven by the motor shaft through one gear reduction. This application is subjected to rapid reversal or plugging, and to the customary dirt and heat of the steel mill. The motor shown is a Crocker-Wheeler size FW, and the bearings on it are similar to those shown in the following illustrations.

Practical Operating Details of

Roller Bearing Service In Mill-Type Motors

Together with Improvements in Operation and The Results of Experience Obtained Under Severe Service Conditions in Steel Mills

By L. J. HESS

Chief Electrician, Youngstown Sheet & Tube Company, Youngstown, Ohio.

THE POSSIBILITY of adapting some form of anti-friction bearing to mill motors has long been apparent to steel mill engineers, but they have been slow to experiment with or adopt either ball or roller bearings. Heavy load shocks from reversal and plugging, added to the ever-present distrust of innovations, has retarded experiment along this line and has caused the use of such bearings to progress very slowly. In this article I shall not attempt to discuss ball bearings beyond pointing out that they have been successfully applied to various types of motors, among which the mine locomotive probably has the heaviest duty, nor treat the subject in a general way, but will tell of my experience with a particular type of roller bearing which has given very satisfactory service on slow-speed, heavy-duty, mill motors.

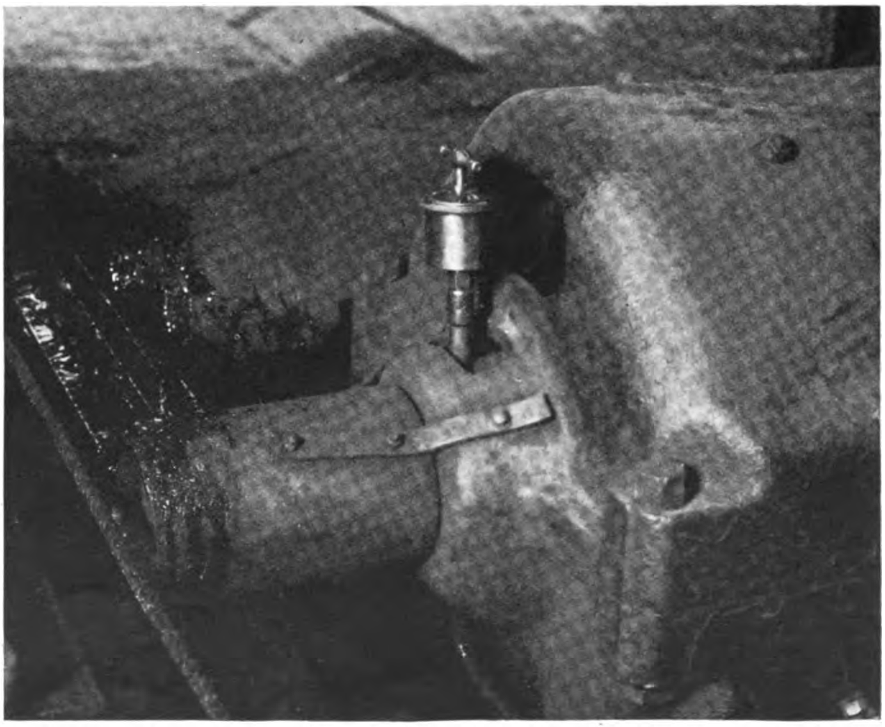
In the application of roller bearings to motors already in service the first problem to be solved is one of design. In the case of the mill-type motor the bearings must be so constructed that they will fit in the present frame, inasmuch as a change of frame is obviously not possible. This is a real problem for the designer. He must carefully consider the space available, the load to be carried, the effect of pinions and brake wheels, and keep constantly in mind the fact that he must use manufacturers' standard parts. He must decide which type of bearing is to be used: the spring-roller type in which the roller is in reality a very heavy spiral spring accurately ground to size on the outside; the taper solid type in which two sets of solid taper rollers in taper races oppose each other; or the cylindrical solid-roller type in which the rollers are confined in cylindrical races. The design of the

shaft also enters into the problem as it will be readily seen that any bearings of the roller type must be a snug, although not tight, fit on the shaft, for the hardened inner race must slip easily onto the shaft. There must, however, be no play or the race will soon wear its way into the shaft. Again, it is necessary that the journal be accurately machined and it is not possible to fit roller bearings on old shafts nor on new ones from the factory because grinding to size is essential. Heat treatment of shafts is also desirable in order that the surface may be harder and tougher so as to withstand the action of the race. Using a steel with 0.50 per cent of carbon, quenched in oil at a temperature of 1,500 deg. F. and drawn back to 850 deg. F., a shaft is obtained which is tough and moderately hard, with the added benefit derived from refinement of grain and improvement of the breaking strength. In case the motor manufacturer's standard shaft has the same size journal as pinion fit, it is necessary to increase this journal size 0.010 in. in order that the race may clear any slight burrs caused by pulling off pinions or brake wheels. This causes no inconvenience, for as was mentioned before, a new shaft is necessary anyway. In this particular design of bearing the question of the fit on the outside of the bearing is not so important, as it is securely clamped between the two halves of the shell. The inner fit has to be exactly right. I may say that so far as hardening of the shaft is concerned, we do not confine this to roller bearings alone. All of our shafts are hardened in the manner mentioned above. We find it is beneficial to put in a hardened shaft whether babbitt or roller bearings are used.

Our first installation of roller bearings was made on a Westinghouse series crane motor used for hoist service. These bearings were obviously an effort to adapt an automobile-type bearing to motor service. This attempt was unsuccessful, however, probably due to the lack of study of the problem involved and to the fact that the manufacturer who furnished them was at that time redesigning his bearings. This try-out occurred about six years ago and as it was unsuccessful was followed by a period of inaction.

THIS IS THE SECOND of a series of articles on bearings of the sleeve, roller and ball designs, that will give the advantages of each compared with the others from the viewpoint of meeting the wide range of service conditions encountered in industrial work. This article on roller bearings was expanded and amplified by the author from a paper which he read before the Association of Iron and Steel Electrical Engineers. INDUSTRIAL ENGINEER invites users and manufacturers to contribute their comments on the information presented in this article and in the other articles of this series. Comments relating to the improvement in bearing operation that actual service has shown, are especially invited.—EDITORS.

This failure convinced me that a great deal of experimental work was necessary in order to develop satisfactory roller bearings for mill motors. During the full swing of the wartime rush few manufacturers of roller bearings were in a frame of mind to give time or thought to the matter. One, however, realized the possibilities and took the time to do some pioneer work. His bearing was of the cylindrical, solid-roller type and seemed well fitted for use on small motors. His engineers undertook to make the necessary designs and build the bearings. These solid-type roller bearings were applied to a Crocker-Wheeler size EW series motor driving, in tandem with a similar motor, the bridge of a 100-ton hot metal crane in a mixer building. This installation was a marked success. Previously on this drive a four-months run on babbitt bearings was considered good, while frequent armature changes, broken bands and flat spots were the rule. At the time the roller bearings were applied the commutator of the armature was badly worn and had an estimated life of three months with babbitt bearings. The winding was in such condition that the installation of a new commutator meant rewinding. After the roller bearings were installed the armature was put in service in April, 1918, and it ran for about nine months, or three times its estimated life on babbitt bearings, before the commutator started to throw bars. The armature was then rewound, a new commutator installed and except for possibly three months during which time minor electrical repairs have been made, this armature has been in continuous service. No trouble with the bearings has developed nor has any grease or oil leaked onto the commutator or windings. A re-



This is a closeup view of the other end of the motor shown in the illustration at the beginning of this article.

A grease cup is used to supply grease to the bearing, because the best of grease evaporates to some extent and the addition of a certain amount of fresh grease is of value.

cent inspection of these bearings shows that they have worn about 0.004 in., which is the ordinary tolerance for a new babbitt bearing.

The next development came in bearings suitable for Westinghouse type K motors, which the manufacturer equips with a bronze, sleeve-type bearing. A difficult problem confronted the designer in this case for obviously a roller bearing will not go in the space provided for a thin bronze-sleeve bearing. But by making a new head, which in the case of the type K motors is a comparatively small casting, it was possible to design a satisfactory bearing. These bearings were installed and have given such good service that, while they have not been in use as long as the others, we have every reason to believe they are just as good.

We had some difficulty in getting the first set of bearings which were sent to us into the frame, as the oil well core had slipped a little. The bearings were designed so closely that they would not go in. It was necessary for us to do some chipping but it did not take long to correct that error. The Westinghouse type K motor is clearly an example of what can be done to improve a decidedly difficult problem in motor lubrication.

The success of these second and third applications encouraged the trial of other sizes and at present roller bearings have been developed for Crocker-Wheeler type SM, sizes CW, DW, EW, FW, and Westinghouse type K, No. 3, 4, 6 and 8 frame motors. These bearings we carry in stock and as fast as repairs to armatures necessitate new shafts and the repair record of the motor indicates the necessity of roller bearings, they are put on. There is one slight disadvantage connected with the use of these roller bearings, in that they cannot be so readily changed as the ordinary split sleeve bearing. We do not attempt to change them out in the mill; all bearings are changed and put on the armature in the shop, as we found by long experience that the other method does not pay. Likewise, when a pinion change is required, a complete armature with new pinion is changed instead. Pinions are changed only in the shop where proper facilities for making such changes are provided.

In Fig. 1, illustration 1, is shown a section of two of these bearings applied to an EW motor armature. The frame of the motor has not been altered in any way. The shaft is 4 in. in diameter for the pinion fit and 4.010 in. where the bearing fits, and is ground to size. The two malleable iron halves are held together by cap screws and clamp the outer race tightly, which serves to keep the alignment. The space between the outer and inner races is completely filled with the rollers, no spacing cage being used. The thrust collar bears against the outer race, which is slightly wider than the inner one, thereby freeing the inner race of any tendency to transmit the thrust through the rollers. Referring to Fig. 1, illustration 1, the thrust is transmitted from the shaft through sleeve *K* to collar *J*, through roller thrust *I* to collar *H*, and thence to the outer shell. The inner race is prevented from turning on the shaft by the feather key *N*, and is a snug slip fit on the shaft, allowing it to move laterally so the thrust bearing can operate, by taking the thrust around the outside of the rollers. Recent experiments lead us to believe that thrust bearings will not be necessary in any size motor unless some abnormal condition is encountered. The thrust bearing locks the armature in one position so that it is not free to oscillate and find its magnetic center. It is better to provide for a floating action of the armature by having the outer race made slightly wider than the inner race. Felt rings prevent the grease from leaving the bearing and any grease which reaches the trap is sent back through a drain channel to the bearing. The bearing is filled with grease through a pipe to which a grease cup is attached. At the commutator end it will be noticed that

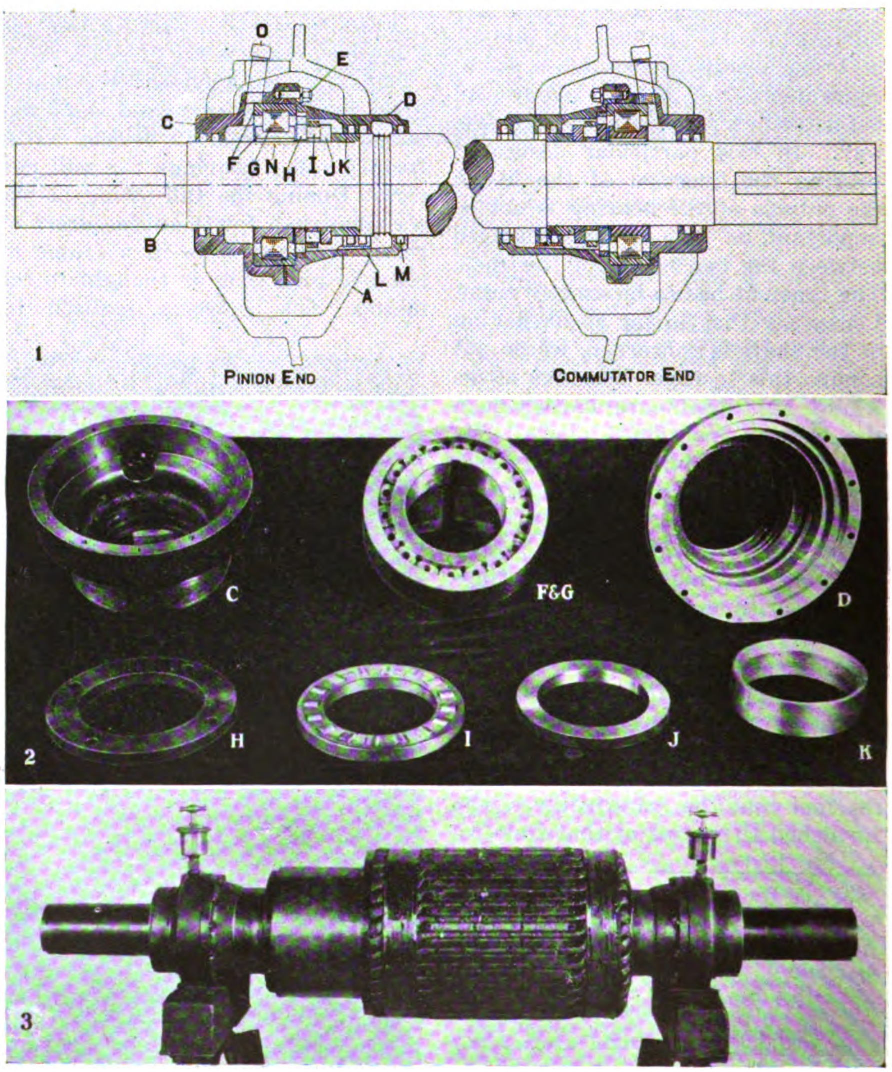


Fig. 1—Roller bearing applied to a Crocker-Wheeler type SM, size EW motor.

In the cross section of the bearing shown in illustration (1) the items are lettered to correspond with the parts shown in illustration (2). *A* is the frame of the motor; *B* is the shaft; *C* and *D* are held together by the cap screws *E* and clamp the outer race *F*; *G* are the rollers; *H* is the thrust collar which bears against the outer race. The thrust is transmitted from the shaft through the sleeve *K*, to collar *J*, through roller thrust *I*, to collar *H*, and thence to the outer shell. In illustration (3) the bearings are shown assembled on the armature shaft as it would leave the repair shop.

the inner felt rings do not bear on the shaft but instead bear on an extension of the armature quill, which is not shown. These bearings are duplicates and can be assembled end for end. In Fig. 1, illustration 2, are shown the parts of the bearing lettered to correspond to the cross section of illustration 1. In Fig. 1, illustration 3, is shown an EW armature assembled complete with bearings ready to go on the mill spare rack.

In Fig. 2 is shown a section of a type K, No. 8 frame Westinghouse motor armature. The shell, *A*, instead of being a bearing shell is the head of the motor and is held to the motor by cap screws exactly as the head which is furnished by the manufacturer. The other parts of the bearing are lettered the same as in Fig. 1 and can be readily identified. This bearing is also furnished with a padded housing to carry a brake. Except for this feature these bearings are interchangeable end for end. In Fig. 2, illustration 2, are shown the parts of the bearing lettered to correspond with the cross section in illustration 1. In illustration 3 is shown the No. 8 type K armature assembled complete with the bearings. In another illustration are shown the parts of the bearing for the No. 3 type K armature. This bearing has no thrust collar or bearing, inasmuch as the rollers and races are themselves ample to take care of the thrust on the small size motor in which they are used.

The lubrication of the bearings is a very simple matter as practically no grease escapes. Once a week the grease cup is given one turn. The grease used is No. 3 Keystone or its equivalent. It is important to see that a good quality of grease is used for lubrication. A semi-fluid grease has been found best. Some trouble has been experienced in that subsequent shipments of grease of supposedly the same quality have not had the same characteristics. This trouble has been overcome by having roller bearing grease tested before use. Any grease showing the presence of fibrous material, filler or talc is promptly rejected as it will ruin the bearings. A temperature test is applied to see whether the grease maintains the same consistency throughout the temperature range that a roller bearing is normally expected to work at. One time a set of bearings failed because one of the men filled the bearing with cheap grease which had in it a large percentage of filler of a non-lubricating nature. The bearing soon started to heat and the thrust was

Eight Advantages of Roller Bearings

THREE HUNDRED sets of roller bearings are now in operation and practically no failures have resulted. From my experience with these roller bearings, I have found that their use offers the following advantages:

1. Electrical repairs to commutators and windings are greatly reduced because fully 50 per cent of these troubles start from oil and grease working their way onto the commutator and front V ring. With roller bearings the grease is entirely confined within the bearing shell.

2. Commutator wear is materially reduced because there is no jumping of the armature due to loose bearings, with its tendency to cause flashing and consequent flat spots. The shafts also are longer lived because the only wear on them is in the keyways.

3. The fact that the armature is held constantly in the center of the magnetic field helps to make the current distribution uniform, thereby relieving the equalizer connections of abnormal duty.

4. Broken bands due to rubbing are unknown.

5. Pinions are kept accurately in mesh and crowding of the teeth with consequent strain and vibration is eliminated.

6. Expense of inspection is somewhat reduced due to better commutation and less attention required for lubrication.

7. The cost of lubricants is reduced to an almost negligible figure as the bearings consume practically no grease.

8. Because of the reduction in repairs it follows that not only is labor and loss of time in the mills during armature changes reduced, but also the delay time charged against the electricians.

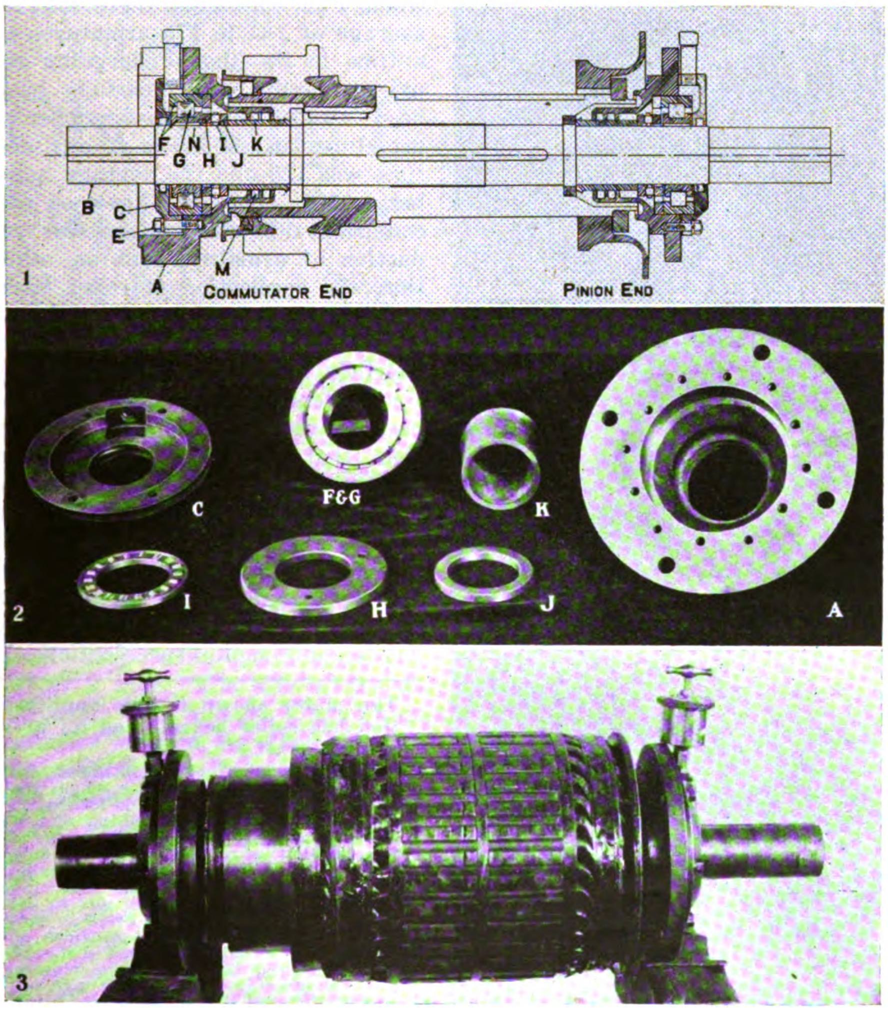
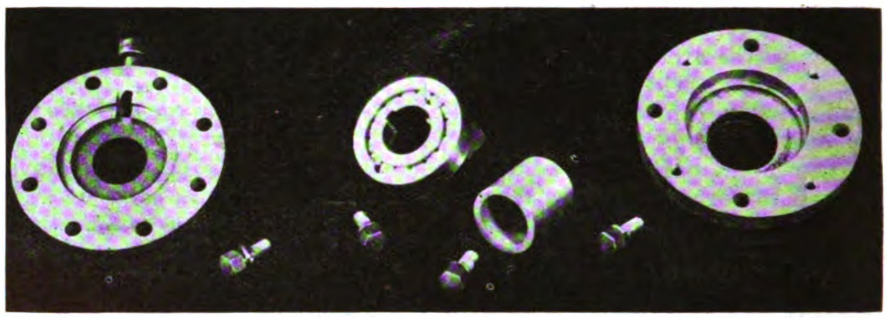


Fig. 2—This is the assembly of a roller bearing for the No. 8 type K Westinghouse motor.

In illustration (1) the sections of the bearing are lettered to correspond with the parts shown in illustration (2). *A* is the head of the motor; *B* is the shaft; *C* is clamped to *A* by the cap screw *E* and thus clamps the outer race *F*; G are the rollers; *H* is the thrust collar which bears against the outer race. The thrust is transmitted from the shaft through the sleeve *K*, to collar *J*, through roller thrust *I*, to collar *H*, and thence to outer shell. In illustration (3) the bearings are shown assembled on the armature shaft.

These are the parts of a roller bearing for a No. 3 type K Westinghouse motor.

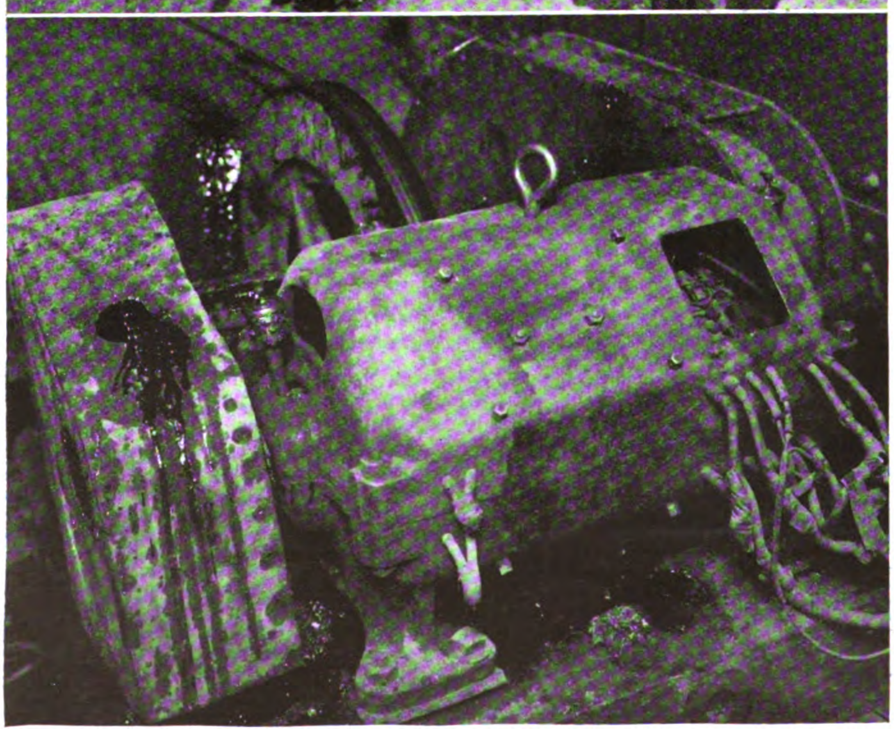
This bearing has no thrust bearing or collar, inasmuch as the rollers and races are themselves able to take care of the thrust on the small size motor in which they are used.



ruined, although the main bearing was not damaged. These bearings consume very little grease and I was once asked why I put on grease cups. The chief reason is that if bearings which are not fitted with grease cups should start to heat there would be no way of putting grease in them. We often find that the best of grease evaporates to some extent and that the addition of a certain amount of fresh grease is of considerable value.

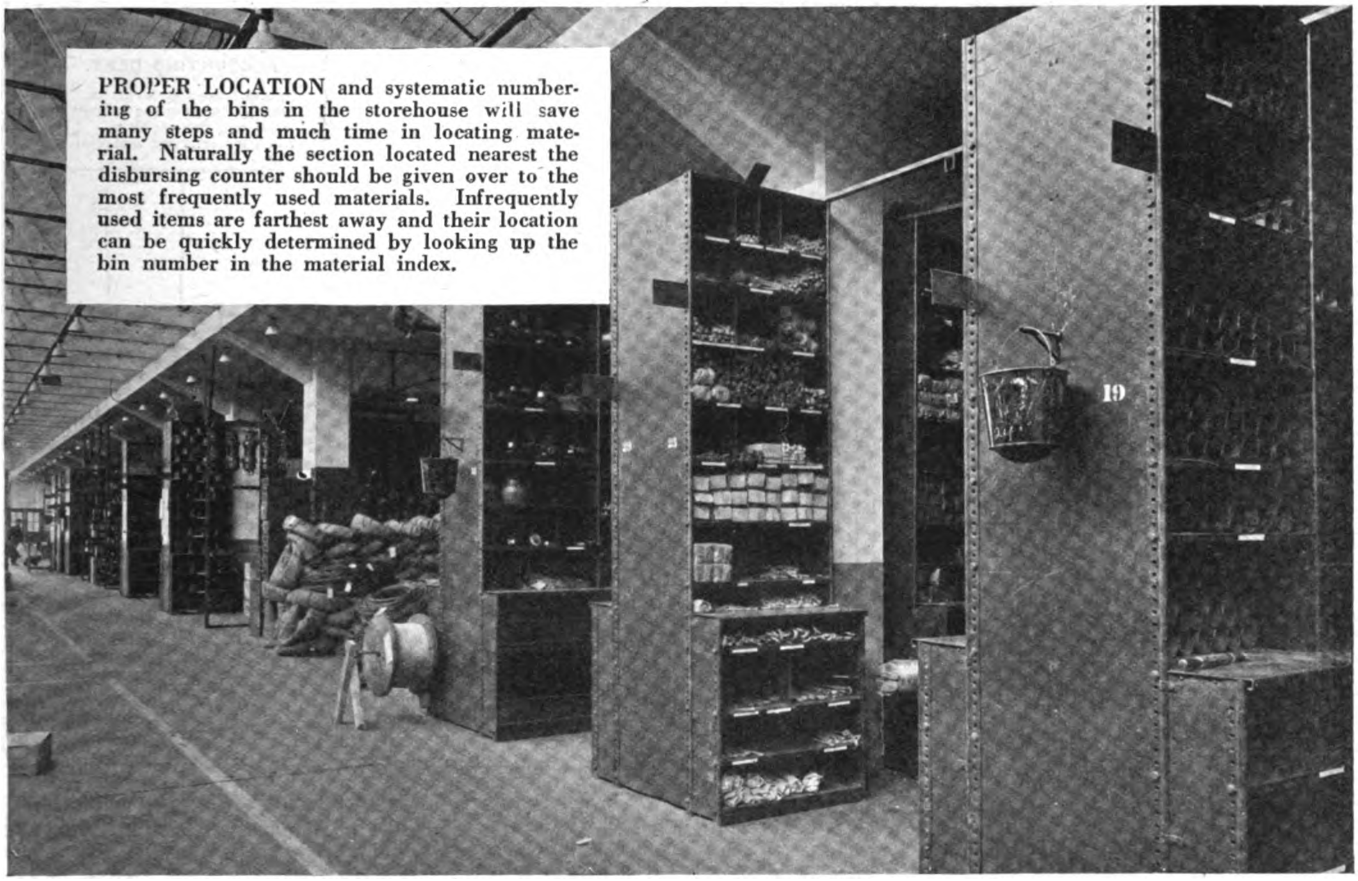
Three hundred sets of roller bearings are now in operation and practically no failures have resulted. From my experience with these bearings I have found that their use results in reduced electrical repair, diminished commutator wear, reduction of band breakage, less pinion maintenance, reduced expense for inspection and lubrication, and less delay time charged against the electricians. These statements are amplified and explained in the box tabulation shown on page 167.

In my opinion the extra expense of anti-friction bearings is more than justified in the savings effected in repairs. As an example, the first installation which I described ran three times as long as we had any reason to estimate it would. This in itself probably paid for that set of roller bearings and the set is still in service and is going to run a long time unless poor grease or an accident puts it out of commission. Before roller bearings were installed in the motors in the plant with which I am connected, there were an average of 165 to 175 armatures at a time in the shop undergoing repairs. Since roller bearings have been installed the highest number of armatures in the shop at any one time was 125 and the average number is 100. I do not know of any condition that could cause this reduction of armature failures, other than the application of roller bearings. I am convinced, therefore, that the mill-type motor with babbitt bearings will be supplanted soon by the roller-bearing motor. It has been proven to my entire satisfaction that by careful designing, roller bearings can be applied to practically any motor at a saving that will soon repay the extra initial cost. When this is fully appreciated by mill engineers, as it is now by some, roller bearings will be written into motor specifications.



The motor shown in this application has roller bearings on its armature shaft.

In the illustration at the top are shown the service conditions under which the motor operates. The drive is located in a pit at one end of the soaking pits of a blooming mill. The motor drives a sheave wheel through two gear reductions. The sheave wheel pulls a cable which draws an ingot buggy carrying the ingots from the soaking pits to the mill approach table. The drive is subjected to plugging and sometimes to "inching" the buggy a short distance. In the bottom illustration the closeup view shows the dirt, grease and oil which surround the drive.



PROPER LOCATION and systematic numbering of the bins in the storehouse will save many steps and much time in locating material. Naturally the section located nearest the disbursing counter should be given over to the most frequently used materials. Infrequently used items are farthest away and their location can be quickly determined by looking up the bin number in the material index.

Step by Step
Details for

Obtaining Equipment and Supplies for Maintenance

Of an Industrial Works, together with Methods of Storing and Accounting for the Material from the Time It Is Received Until It Is Used

By J. ELMER HOUSLEY

Electrical Engineer, Aluminum Company of America, Alcoa, Tenn.

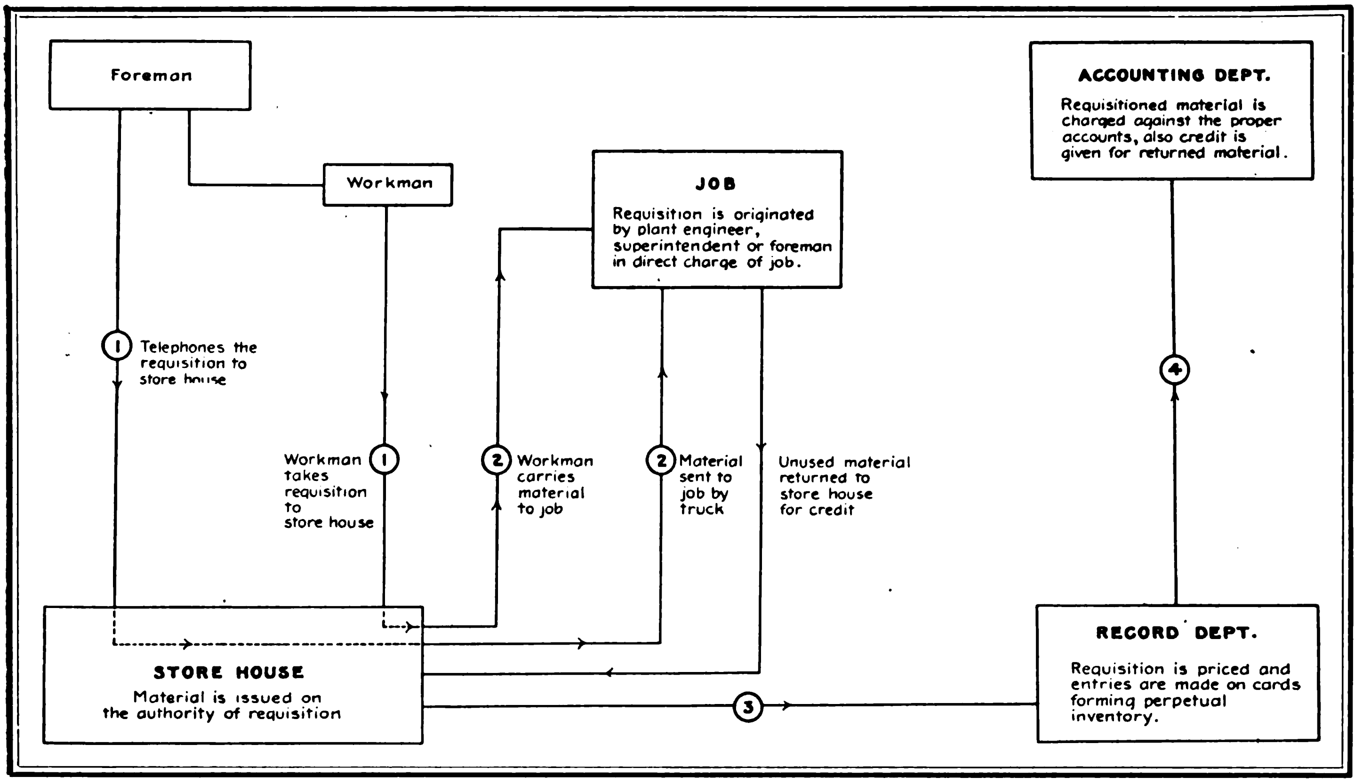
THE FUNCTION of the storekeeping department of an industrial plant may be compared to the service performed by a single large department store supplying a city. The size of the department store and the kind of commodities handled are determined by the requirements of the customers. Considering the single unit of electrical stores, the requirements of such a department are analyzed by the same methods that the merchant would use. Success is measured by the quality of service given. Real service means that there must be maintained at all times an adequate supply of materials for construction and maintenance work in the plant. The rate of turnover must be watched on all items in regular use and the wants for special jobs and seasons must be anticipated. Under centralized control of the purchasing agent materials are collected from jobbers, manufacturers, sales agents and other dealers, checked, and put in stock until ready to be utilized on the job.

The centralized control of material in a general storehouse is a great advantage over the method of having each plant department store the materials required by that department. Loss of material is minimized, duplication of stocks is eliminated and overhead is cut down. Access to the material is not obtainable except by those regularly employed in the storeroom.

THIS ARTICLE TELLS how the industrial plant organization determines what material it will need in the future, what is done to obtain it, how the required material is gathered from a great variety of sources, how it is stored until a breakdown requires a particular repair part or the material is needed in the construction of a certain job and how the given material is kept track of, from the time the need for it is foreseen until it is actually used on the job.

Storehouse Equipment Should Be Arranged Conveniently

The physical equipment of the storehouse of the plant in question consists of sectional type of metal framework arranged to form bins. The size of the bins is adjustable and may be changed as the stocks of given items carried, may change. These bins are arranged in stacks placed back to back with an aisle in front of each stack. At a convenient counter height is an extension shelf. This gives more space in the bins below the shelf and also provides a convenient place for material when checking, or the shelf may be used as a step in reaching the higher bins. The construction of the equip-



This diagram shows how the desired material gets from the storehouse to the job and how the proper department is charged for the material.

ment is such that a shelf may be changed to a bin simply by adding a bin-front attachment, or the shelves may be split up into any desired arrangement by crosswise or lengthwise dividers. Drawers of various sizes are provided to fit on part of the shelves. On each bin shelf or drawer is a cardholder which carries the bin number and a description of the material located in that compartment.

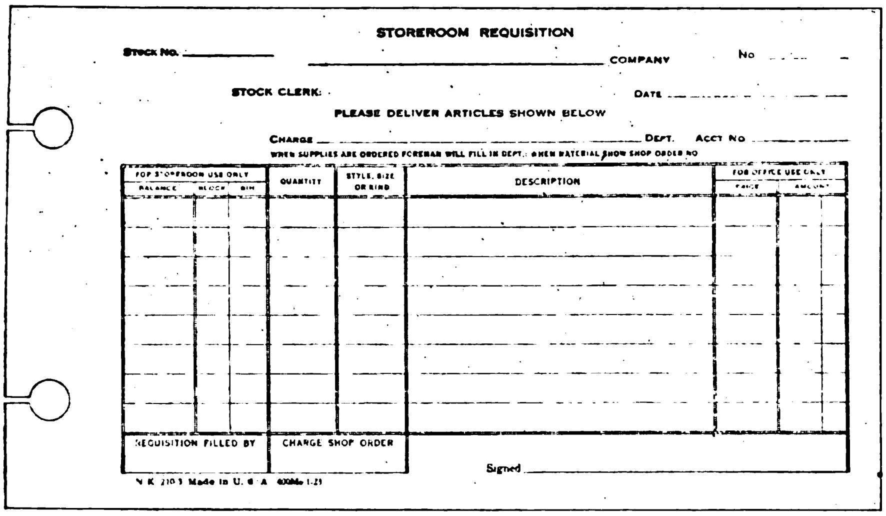
Near the rear of the storeroom, shelves are provided for the material that is too large to be conveniently stored in bins. The two sections nearest the counter or window through which material is delivered are given over to the most commonly used items such as bolts, nuts, and screws. Then comes the fuse link and fuse stock section. The next section provides for conduit fittings, wiring and insulating materials. The fifth section provides for compensator fingers and contacts, repair parts for control equipment of electric trucks, locomotives, elevators, and other small drives. The next section is utilized for line hardware, insulators, and also potheads and other lead cable fittings. Shelves to one side and to the rear of the bin section are used for safety switches, meters, current transformers, lighting fixtures and reflectors. A reel of No. 14 wire is kept in this section. All other wire and cable, including a large stock of round and rectangular magnet wire for rewinding motors, is kept on the third floor of the storehouse. On the fourth floor, space is provided for compensators, motors and small transformers. The large transformers are kept outside in a crane yard as they are built for outdoor service and are not affected by weather. It is very essential to store motors and compensators in a heated building during the winter in order to prevent them from sweating, for moisture in the air condenses on the metal parts and deteriorates the insulating materials and rusts the iron parts. Small and valuable items such as flashlights and flashlight parts are kept under lock in the storekeeper's office. Material that is likely to be stolen, such as lamps, is kept in a "lock up" section of the main storeroom. All lamps are marked with the company name by means of an etching fluid.

Arrangements are made for convenient handling of the material both into and out of the storehouse and to the place where it will be used. Motors and compensators are handled by hand trucks and by platform lift trucks or handled on rollers using the skids attached to the motors for shipment. Incoming material may be handled directly from a railroad car at the storeroom dock or from a motor truck or industrial electric truck along the same dock. A monorail carriage with a 1-ton chain block is provided for unloading purposes. Motors weighing over 2,000 pounds are stored in a wing extending from the main floor of the storehouse, which also houses rough stores such as small castings, shafting, sheets, conduit and pumps.

The delivery of material from the storeroom to the jobs scattered over the large area of the plant is handled by electric industrial trucks.

Procedure for Obtaining Material from Storehouse

Withdrawal of electrical material can be made only by those in authority in the *Electrical Department*, or at night by the night master mechanic. Several sample signatures are furnished the storekeeper from each authorized person. Usually these will be the electrical engineer, chief electrician, office assistant, shop foreman and construction foreman. A storeroom requisition, or store ticket, signed by one of these men is taken for every lot of material issued from the storeroom. The storeroom requisition blank shown in one of the illustrations provides space for the job number. Whether the job is regular repair and maintenance, special repair and maintenance, or construction, is indicated by the series of numbers used. Space is provided for the


STOREROOM REQUISITION

Stock No. ______ ______ COMPANY No ______

STOCK CLERK: DATE ______

PLEASE DELIVER ARTICLES SHOWN BELOW

CHARGE ______ DEPT. ACCT NO ______

WHEN SUPPLIES ARE ORDERED FOREMAN WILL FILL IN DEPT. WHEN MATERIAL SHOW SHOP ORDER NO

FOR STOREROOM USE ONLY			QUANTITY	STYLE, SIZE OR KIND	DESCRIPTION	FOR OFFICE USE ONLY	
BALANCE	BLOCK	BIN				PRICE	AMOUNT

REQUISITION FILLED BY | CHARGE SHOP ORDER | Signed ______

N K 2103 Made in U. S. A.

Material is obtained from the Storehouse on this requisition.
This is known as the storeroom requisition or store ticket and is the authority for the *Storehouse* to disburse the required material. This form also shows the *Accounting Department* what job or department is to be charged for the material requisitioned.

quantity and description of the material. The price extensions are made by the record clerks in the *Record Department.*

The procedure in putting through a storeroom requisition, except for very small items passed over the counter on presentation of a requisition, is as follows: The foreman telephones to the order clerk in the storehouse, giving his name, job number, the building station number where the material is to be delivered, and the quantities and items desired. The storehouse clerk takes the requisition, assembles the items and places the requisition in a binder which has the building number stamped on the outside. The truck driver gathers the material intended for the buildings on his assigned route, loads up his truck and takes the material to the point designated as the station shown on the requisition. The mechanic on the job signs for the material. Hence it is seldom necessary for a mechanic or helper to leave the job to secure material.

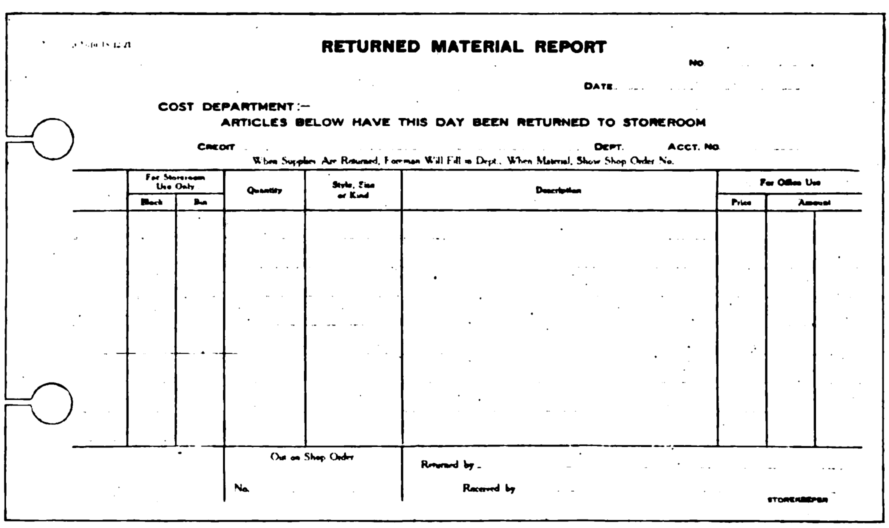
The record of storehouse transactions is handled by a sort of clearing house called the *Record Department.* A card index system covering every item in stores is arranged to form a perpetual inventory. Receipts and withdrawals of material are entered on the cards and each card is balanced to show the amount of that item remaining in the bin. Each card is marked with the bin number housing that item. The bin and shelf divisions are lettered alphabetically, a letter to each side of a double stack of bins, and the bins are numbered from one up on each side of the stack. If a material item card states that the material is located in bin H2, it is a simple matter to walk to the rear side of the fourth section and reach the item on the top row of bins, the second bin from one end of the stack. The invoice is used for entering the items on the record cards together with the cost of that lot of material. The date of entry is noted on the card. The withdrawals are entered from storeroom requisition blanks with the date of requisition noted. The additions and subtractions are balanced at all times and the quantities of any given item may be known at once by referring to the material card. A valuable function of this card is to furnish information as to the rate of consumption of material over any given period. This will be considered later.

Since the cost of different shipments of the same item may vary, the average cost is used in pricing the storeroom requisitions. After the quantities are entered on the record card the storeroom requisition is sent to the *Accounting Department,* where the items and costs are entered in the accounts against each job number. In this way accurate costs are obtained for any construction, repair or operation job. Material which is left over on a job, if in good shape, is returned to the storeroom with the "Returned Material Report" blank shown in an accompanying illustration. This form gives the shop order number or the department to be credited, together with quantities and description of items.

When and How the Purchase of Supplies Is Authorized

One of the most interesting and difficult phases of maintaining electrical stores is the determination of stock requirements. The storekeeper is required to maintain a stock of the staple articles which are in every day use and consumed at a definite rate. The "ordering point" or the minimum stock on hand when more material should be reordered, is determined by the storekeeper, the electrical engineer and the chief electrician. The factors considered are the nature of the material, the quantity normally consumed in ninety days, the prevailing delivery schedules and whether the market is advancing or declining. The quantity to be ordered is usually the consumption for the previous ninety days.

The repair parts, whether special


RETURNED MATERIAL REPORT

NO ______

DATE ______

COST DEPARTMENT:—

ARTICLES BELOW HAVE THIS DAY BEEN RETURNED TO STOREROOM

CREDIT ______ DEPT. ACCT. NO ______

When Supplies Are Returned, Foreman Will Fill in Dept. When Material, Show Shop Order No.

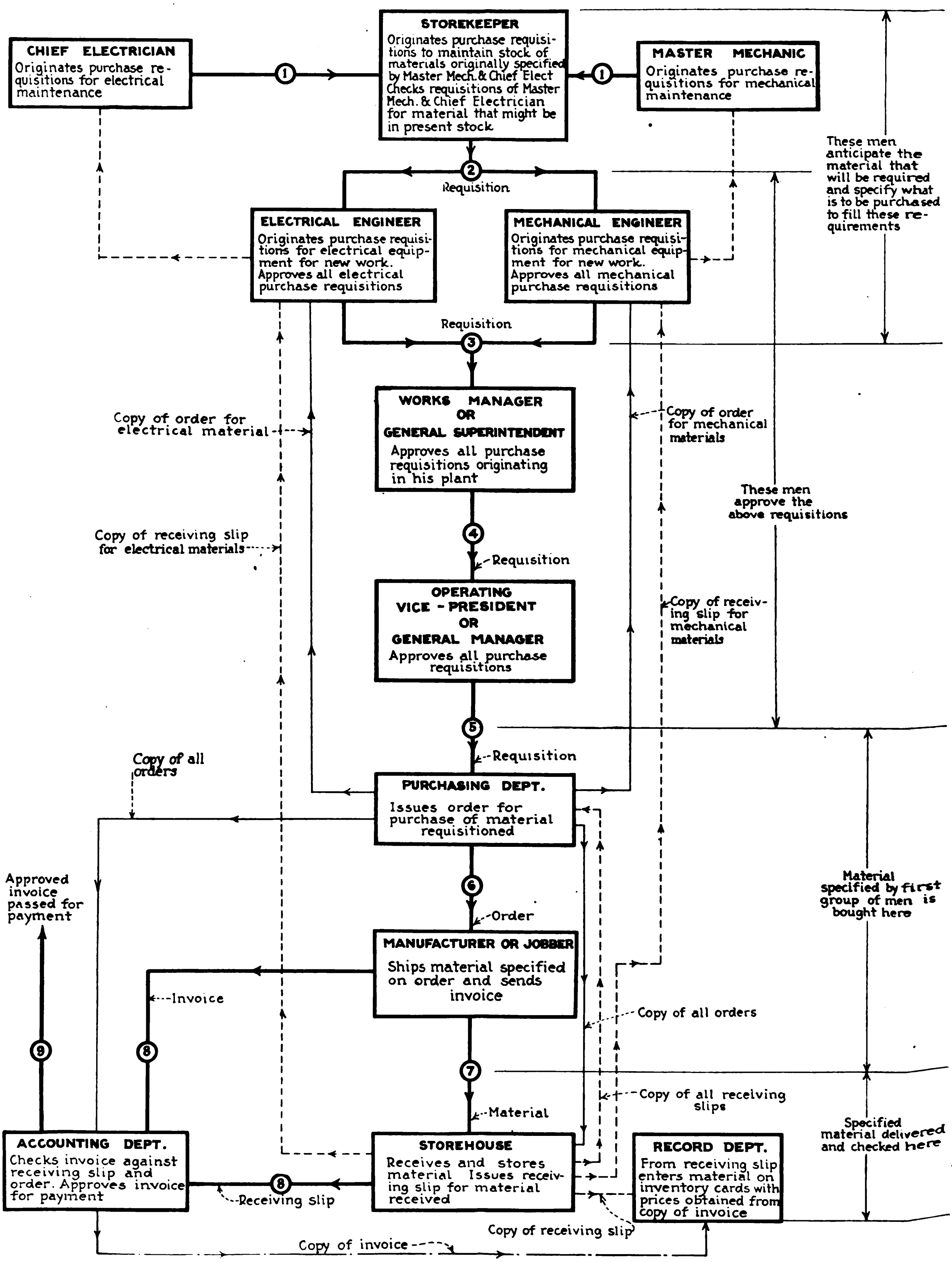
For Storeroom Use Only		Quantity	Style, Size or Kind	Description	For Office Use	
Block	Bin				Price	Amount

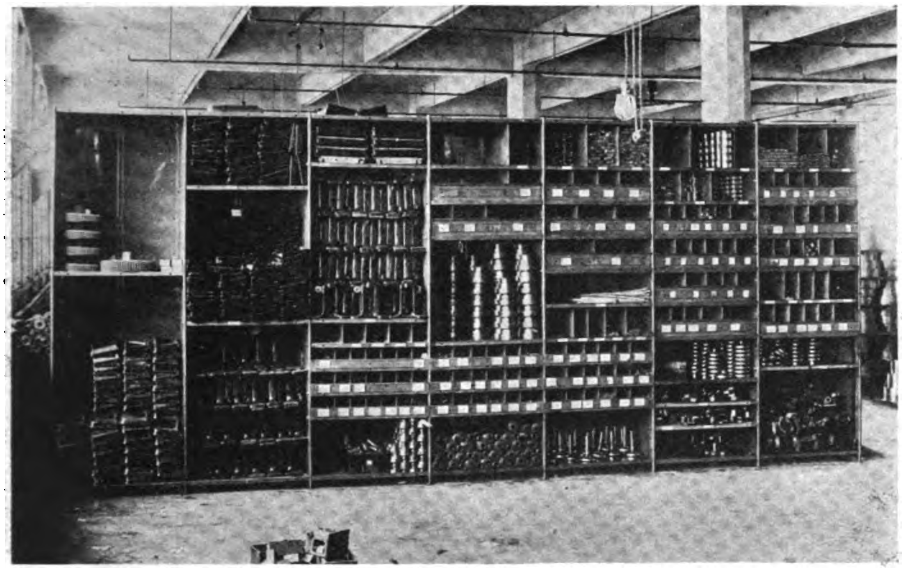
Out on Shop Order No. | Returned by ______ Received by ______ STOREKEEPER

This form is used for returning material to the Storehouse.
This is known as the returned material report or credit memorandum. By the use of this form the *Storehouse* acknowledges the return of the material and the *Accounting Department* credits the job or department from which the material was returned.

How Orders for Material Start and Path They Take Through the Works

Including the Steps by Which Equipment and Supplies Needed for New Work, Operation, and Maintenance Are Secured and Delivered to the Works. The Numbers in the Diagram Indicate the Sequence of These Steps





This picture shows how conveniently steel shelving or bins can be subdivided to suit the material in them.

As the stock varies the size of the bins may be expanded or contracted to suit the requirements. Some of the shelves pictured are carrying loads of 2,000 lb.

or regularly used, are specified on a purchase requisition by the chief electrician who is in close touch with the repairs under way. The quantities used during a given period are subject to erratic variations. These are influenced by conditions in the operating department, the labor turnover (indicating the number of green operators), and the skill and morale of the repair organization. With such items as compensators and switches, if a sufficient number of spares are on hand it is well to let the damaged equipment accumulate in the shop for one or two months and then order about double the quantity of material necessary to repair the equipment on hand. Parts such as fingers and contacts for compensators and controllers are usually ordered in lots of 100, 50 and 25 pieces as determined by the amount of such apparatus in service and our experience as to the life. The small fingers and contacts usually last from one to one and one-half years and in the larger control equipment from two to three years. In ordering magnet wire, close check is made of the number of times we have re-wound motors using a common size of magnet wire. If this is not done a surplus stock of rectangular wire is likely to accumulate and remain in stores for a long period of time as an idle, interest-eating investment. For motors having sizes of wire seldom used we delay buying wire until the motor comes in for repairs and the minimum amount of wire possible is bought. For special apparatus of vital importance one set of necessary parts is kept on hand and replacements are ordered as these parts are used. This applies to parts for elevators, automatic telephones, cranes, automatic control, fire alarms and similar equipment.

The electrical engineer originates purchase requisitions for electrical material intended for new work. In case the job will amount to more than $500, a special authorization is prepared with estimates of cost and necessary data as to why the job is required or what savings will be obtained by its installation. After it has been approved by the higher executive officials of both the local and the parent companies, the required material is requisitioned.

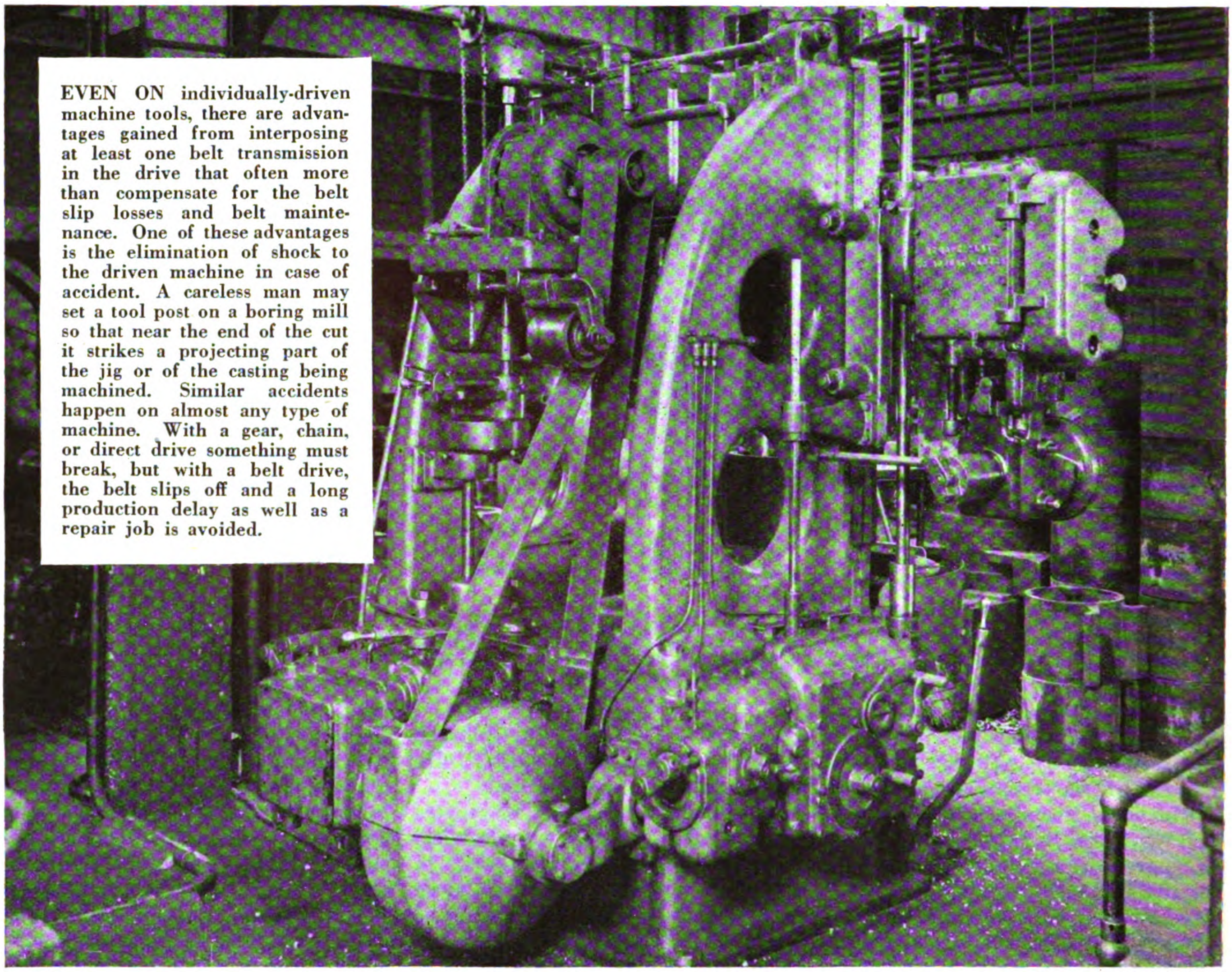
All purchase requisitions from the storekeeper for electrical material and from the chief electrician pass through the hands of the electrical engineer for approval as to the quantities and specifications, so as to prevent duplication of orders and the purchase of obsolete or unsuitable material. The requisitions then pass through the hands of the works manager or general superintendent of the local plant for approval and are finally approved by the general manager or operating vice-president of the company.

The *Purchasing Department* receives the approved requisition and issues an order to a manufacturer or jobber covering the purchase of the material. Copies of this order are sent to the electrical engineer, the *Storehouse* and the *Accounting Department*. The manufacturer ships the material to the plant and sends the invoice covering the goods. The *Accounting Department* gets the invoice and the *Storehouse* receives the material. The *Storehouse* makes a memorandum, called the receiving slip or the receipt entry, of the goods received. Copies of this are sent to the electrical engineer, the *Record Department* and the *Accounting Department*. The *Accounting Department* checks the receiving slip against the order and the invoice and if everything is correct, it passes the invoice for payment. The *Record Department* receives a copy of the invoice so that it may make the entries on the record cards covering the items of material, and determine the average price at which the material is to be charged out.

A copy of all *Purchasing Department* orders for electrical materials is furnished to the electrical engineer.

Certain items carried in the electrical stores should be bought on specification and tests made on the material upon arrival in the receiving department. This applies chiefly to large plants where the material is bought in fairly large quantities and usually direct from the manufacturer. The smaller companies should make less elaborate tests, based somewhat on rule-of-thumb methods or a physical comparison between samples taken from orders from various firms. Where possible the electrical engineer should work with the chemical engineer and determine the physical and chemical nature of the material to be purchased before writing up specifications. They should also develop a routine method of testing the material received. At times material may be checked in by a receiving clerk without a careful or competent noting of discrepancies between material and specifications.

Often the material has been used and found unsatisfactory and a considerable loss may result which may be avoided by having certain classes of material sampled, tested and approved by the chemical engineer's organization. Some of the items which are susceptible to variations and should be tested are: insulating varnishes and paints, insulating cloth and paper, web tape, rubber insulated wires, acid and caustic battery solutions, transformer and compensator oils and lubricating oils.



EVEN ON individually-driven machine tools, there are advantages gained from interposing at least one belt transmission in the drive that often more than compensate for the belt slip losses and belt maintenance. One of these advantages is the elimination of shock to the driven machine in case of accident. A careless man may set a tool post on a boring mill so that near the end of the cut it strikes a projecting part of the jig or of the casting being machined. Similar accidents happen on almost any type of machine. With a gear, chain, or direct drive something must break, but with a belt drive, the belt slips off and a long production delay as well as a repair job is avoided.

Some of the Hows and Whys for

The Layout of Group and Individual Drives

Together With Special Features Determining the Layout of Fan Drives and the Results of Tests on Lineshaft Friction Losses

By ROBERT W. DRAKE

Electrical Engineer, McCormick Works, International Harvester Company, Chicago, Ill.

A DETAILED ANALYSIS of the reputed advantages of individual drives compared with group drives will show that the latter have a much wider field than is commonly supposed. However, each type of drive has its field where it is generally admitted to be unwise to attempt to apply the other.

The following article offers suggestions for the layout of belts, gearing and direct connection as applied to both individual and group drives. Belt drives should be designed conservatively, especially the drive from motor to lineshaft. The arguments against group drive based on speed variation, belt slip and the like, can be almost entirely eliminated by designing drives with bottom pull on the belts rather than top pull, and with ample belt area. Mr. Frederick W. Taylor's classical paper* in which he proves that, all relevant factors considered, the total annual cost of belt drives is least when the belt tension is approximately half the usual American practice, is as true now as it was when he made his painstaking experiments.

The horsepower that may be transmitted by a belt varies with the belt speed, other factors remaining constant. However, at speeds above 5,000 ft. per minute, the centrifugal force tends to lift the belt from the pulley and so decreases the friction contact which gives a belt its pulling power. The best belt speed is about 4,000 ft. per min. Most standard motor pulley sizes are not large enough to give this speed. Where the space between lineshaft and ceiling is sufficient, it is better to install a large lineshaft pulley and a motor pulley large enough to give approximately the above speed. The decreased bearing troubles due

*Proceedings A. S. M. E., Vol. 15.

to diminished belt stresses, the reduced cost of belting and lessened slip will repay careful design in each case.

In the case of machine tools, there are also sufficient advantages in interposing at least one belt transmission in the drive, so that this has of late years become standard practice in many progressive industrial plants, even on individually-driven machines. Where such practice is deemed best about half the belt-slip losses and belt maintenance are retained in order to gain advantages which more than compensate.

One of the advantages is the elimination of shock to the driven machine and to the motor in case of accident. Such accidents are of daily occurrence in a large, individually-driven plant. A careless man sets a tool post on a boring mill so that near the end of the cut it strikes a projecting part of the jig or of the casting being machined. Similar "accidents" happen on almost any type of machine. With a gear drive something must break but with a belt drive the belt slips or comes off and a long production delay as well as a repair job is avoided.

Attempts have been made to design this type of belt drive so that the driving motor could not be so grossly overloaded. This has not proved practicable. Many such drives must start against a severe inertia load, and must carry an intermittent load with relatively high peaks. Anything short of a very conservative belt drive will give constant trouble at such times and offer more handicaps to output than it eliminates.

Recommended Standard Speeds for Each Size of Motor

In the preceding articles in the February and March issues, much stress has been placed on spares. In a plant in which group drive is the rule, the choice of a standard speed in each motor size is of importance. A proper compromise between the conflicting demands of the different sorts of service for which motors will be needed, will minimize the number of "off standard" motors which must be tolerated (and duplicated if they are on important drives). It is necessary also to keep in mind the fact that the higher the speed of the motor, the lower the cost, and the higher the efficiency and power factor. Everything considered, I have found the following to be the most desirable speeds in 60-cycle, alternating-current motors:

1/4 to 3 hp.	1,200 r.p.m.
5 to 50 hp.	900 r.p.m.
75 to 100 hp.	600 r.p.m.

THIS IS THE THIRD of a series of three articles that analyze the advantages of group and individual drives. The first article, which appeared in the February issue, pointed out the principal reputed advantages of individual drive. The second article was published in the March issue and discussed fully the principal reputed advantages of group drives. This article will offer suggestions for the layout and installation of individual and group drives.

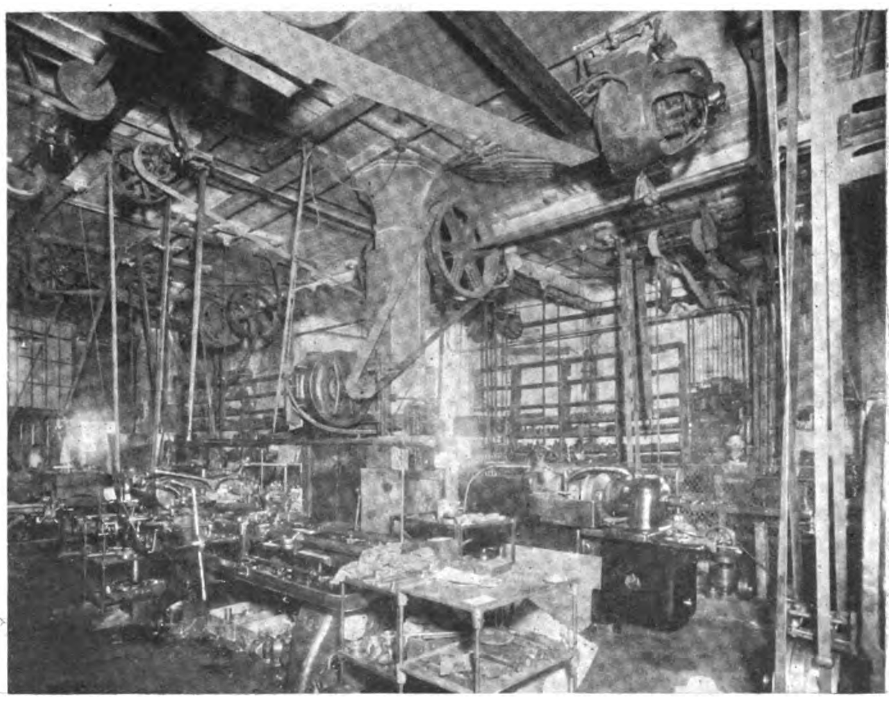
Factors Governing the Layout of Lineshafting

For general manufacturing the balance between cost, lineshaft losses and mechanical suitability is struck at about 200 r.p.m. for lineshafts serving groups; for shafts serving grinding and similar high-speed machinery exclusively, lineshaft speeds may sometimes be as high as 400 r.p.m. to advantage; for groups containing assorted woodworking machinery, a speed in the neighborhood of 300 r.p.m. generally works out best.

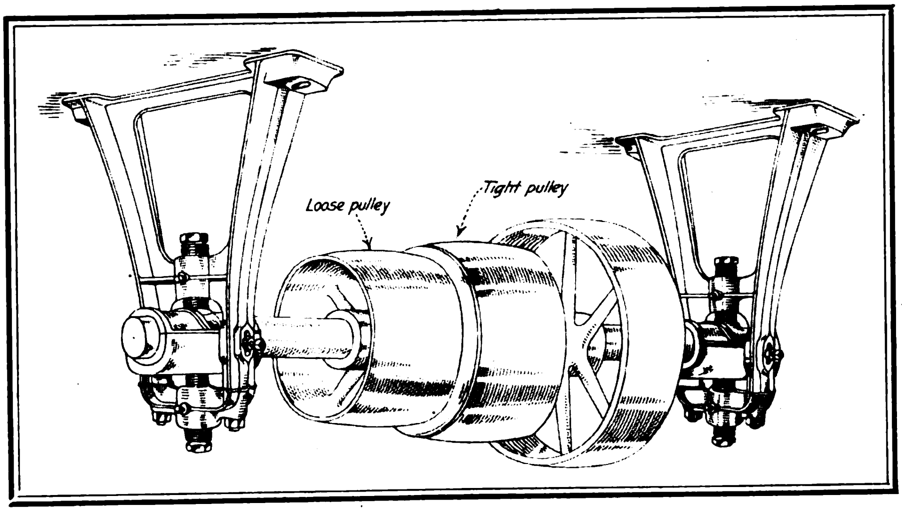
Countershaft Friction Is Major Part of Lineshaft Losses

I will risk a digression at this point to discuss the results of a series of service tests on lineshaft friction. The tests were undertaken to obtain a service check on laboratory experiments on relative friction with babbitt bearings using various grades of oil, each with and without Achison's "Oildag" and were later extended to include ball bearings for comparison.

A room of woodworking machinery was chosen for the comparative tests because the lineshaft speed was 50 per cent higher than the lineshaft speed in general use throughout the plant, and the shafting friction losses might be expected to be thereby increased. The bearings were of the wick self-oiling type, a special design developed at this works in the old engine drive days. Wick-oiled bearings are nowadays considered to be old-fashioned, but this design is admirable indeed as to reliability and, by comparison with other published tests, has remarkably low friction. The wick design has one advantage that is seldom sufficiently emphasized and is a worthwhile advantage in dirty locations; this is the fact that the oil, in recirculating, passes through the



The best belt speed is about 4,000 ft. per min.
However, the difference between the required lineshaft speed and the motor speed may be so great that it is impracticable to use pulleys large enough to secure the proper speed reduction and maintain such a belt speed. In the picture shown this is the cause for the low belt speed. One way of getting around this is to make the speed reduction in two steps, using a jackshaft between the motor and the lineshaft.



Special design of tight and loose pulleys which is arranged to reduce friction losses when idling. The loose pulley is somewhat smaller in diameter than the tight pulley so as to relieve the belt tension when idling, thereby prolonging belt life and decreasing bearing friction. The loose pulley is wider on the flange side and has a higher crown than the tight pulley. This keeps the belt in the center of the loose pulley and prevents wear on the edge of the belt.

wick by capillarity, and thereby the dirt and grit are separated out. The decreased wear from this cause is very marked, especially in foundries and other places where abrasive dust is normally present in the air.

To accurately determine the power required to run the shaft under test, a special small motor was belted to it, in placé of the large motor required to carry the regular load when the driven machines are running. The input to this motor was determined each day at noon with shaft running, but all machines shut down. A week or more was allowed after each change in lubricant for bearing conditions to become constant. After several months comparative testing with different oils in babbitt-lined bearings the main lineshaft was equipped with ball-bearing hangers, but the looked-for startling reduction in friction did not appear. This suggested that a determination be made of the main lineshaft friction with no countershafts running. We were surprised to find that only 17 per cent of the friction in this room was in the main lineshafting, and that the remaining 83 per cent was in the countershafting.

When the drive belts on the ordinary "tight and loose" style of countershafts are on the loose pulley they sometimes take such a position that one edge drags on the tight pulley for 1/8 in. to 1/4 in. This seemed to be a partial explanation of the relatively high countershaft friction in this case. A design of loose countershaft pulley somewhat smaller than the tight pulley, with flanged approach to the diameter of the tight pulley and a rather abnormal crown has been used more or less for many years, but has never come into common use. This design is shown in an accompanying illustration. Since the increased cost is trifling, it would seem in the light of this experiment to be worth adoption, at least in cases of special countershafts built within the plant, and in maintenance replacements.

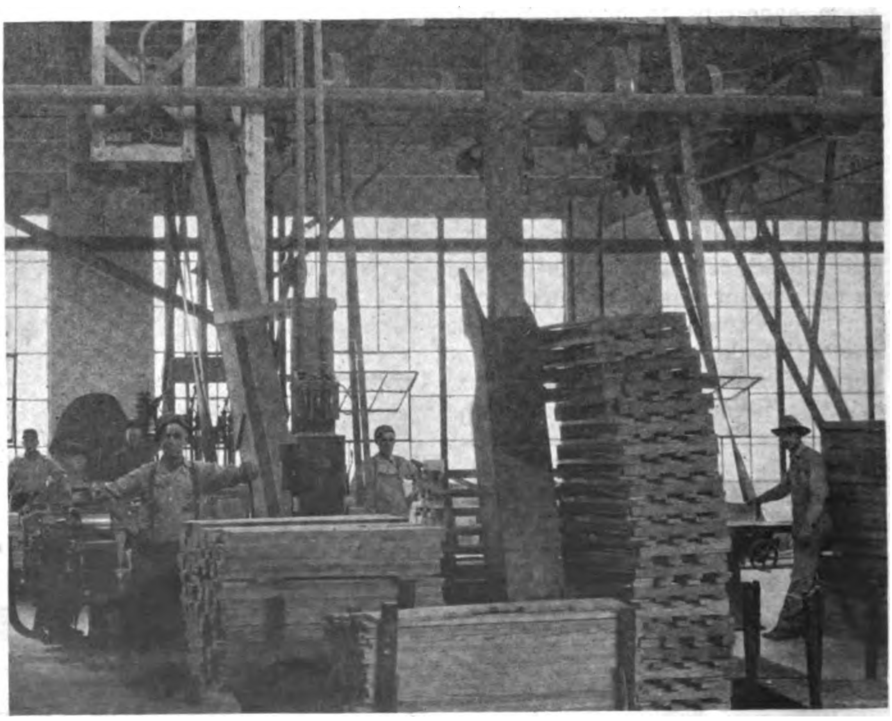
Slow-Speed Motors are Preferred for Geared Drives

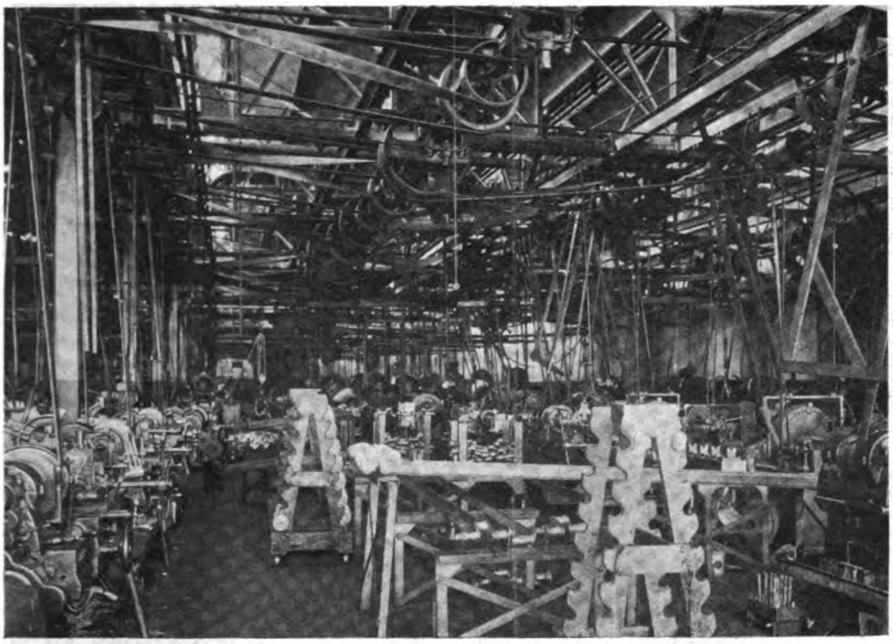
Except in the case of very small motors (1 hp. and below) slow-speed motors are preferable for gearing if reliability is of any importance. The slower-speed motor is built in a larger frame with a heavier and sturdier shaft which is better able to endure the shock of gear drive. The slower shaft speed allows a greater pinion diameter without exceeding conservative peripheral speeds at the pitch line, and this in turn permits the use of a coarser pitch on the pinion, with consequent greatly increased life and reliability, on the first gear reduction. Especially is all this true of the excessively light designs of continuous-rated motors which have been marketed during the past few years by the larger manufacturers. The bearings in these motors are generally die-cast without shells. If satisfactory bearing life and reliability are to be obtained, it is almost necessary to operate such motors with compressed cloth, molded composition, or rawhide pinions. In applications where such pinions will not stand up it is advisable to use sturdier motors.

Considerations Affecting the Design of Fan Drives

In general, fans are best driven individually, but this is by no means a universal rule. Small and moderate-sized exhausters can frequently be grouped with the machines which they serve (for example, grinders, buffing wheels, and the like) while less frequently it is advantageous to group blowers with the machines served. The fact remains that even

A lineshaft speed of 300 r.p.m. generally works out best for groups of assorted woodworking machinery.





Many factors are involved in laying out a group drive similar to the one shown.

There is the determination of the motor speed to use, the most efficient belt speed, the factors governing the selection of pulleys, and the selection of the lineshaft speed, which is based on the balance between cost, lineshaft losses and mechanical suitability.

in plants which are group driven in general, most large and many small fans are individually driven. At first thought a direct-connected unit appears to offer many advantages, but I prefer to belt fans whenever possible. There are various advantages for and against this practice.

The exact predetermination of performance in a fan system is more difficult than most ordinary engineering layouts. It is much easier to predetermine pressure drops in electrical, steam, or hydraulic layouts than in fan piping. A fan system is full of bends, offsets and elbows, to avoid obstructions. These "fittings" can seldom be made to follow any definite standard as to curvature, but owing to the relatively large size of ordinary fan piping, they must be laid out individually to suit the space available. Frequent changes from round to rectangular ducts and back again are often required. Estimates of resistance to flow through such "fittings" are of necessity rough. In water, steam and electric transmission, standard pipe (or conductors) and fittings are universally used and their resistance is known to a far greater degree of precision.

In steam and water piping the condition of the inside surface plays an important part in determining the resistance, but the effect of incrustation plays a less important part in determining flow than is generally the case with fans. The degree and rate of incrustation in fan piping depends upon so many variables that it varies from place to place in the same system of ducts (due to variation in velocity). Between different installations in approximately the same service, the variation in incrustation due to variation in oily vapor carried in the air, fineness and density of material handled, is astonishing. It is seldom possible to clean fan piping effectively except the main ducts, and these only when they are large enough for a man to pass through.

The result of all this is that once a fan system is in service, a little testing will very frequently show that a moderate change in pressure will be beneficial. Such a change can best be effected by varying the speed of the fan. The pressure delivered by a fan connected to a fixed duct system varies as the square of the speed and the horsepower required to drive it varies as the cube of the speed. Thus if tests show that a decrease of as little as 10 per cent in speed will give satisfactory performance, there will be a saving in horsepower of 30 per cent. When we consider that the power required to operate an average exhauster system using efficient modern slow-speed fans serving woodworking equipment or grinding machinery often equals or exceeds the power requirements of the machinery served, it is evident that such a saving is well worth while. If the case is reversed, and the operation of the fan is less satisfactory than expected, frequently a slight increase in speed will set matters right again and give ideal service. As time goes on, the resistance of the pipe frequently increases with gradual roughening of the pipe due to deposit of foreign matter. Eventually a higher pressure or suction is necessary to obtain good results.

From time to time load may be added or removed from the system, increasing or reducing the horsepower and in some cases the speed required to drive the fan for satisfactory operation. Within reasonable limits, all such changes in condition may be met by changes in the speed and horsepower of the fan drive. No such changes are ordinarily possible with a direct-connected fan, particularly with alternating-current drive. With a belted fan small changes may be effected at a minimum expense, delay, or trouble by merely changing motor pulleys. Greater changes requiring a change in horsepower outside the economical power factor and efficiency range of the motor originally installed, or beyond its capacity, can be easily made by a change to the next size of motor with a suitable pulley.

Belting fans has the great advantage that it permits the use of motors which are standard as to speed and horsepower for lineshaft drive in the plant and for which spares are therefore available in case of motor trouble. Further, the time required to replace a burned-out motor is ordinarily far more with a direct-connected unit than with a belted unit unless a flexible coupling is used with the former.

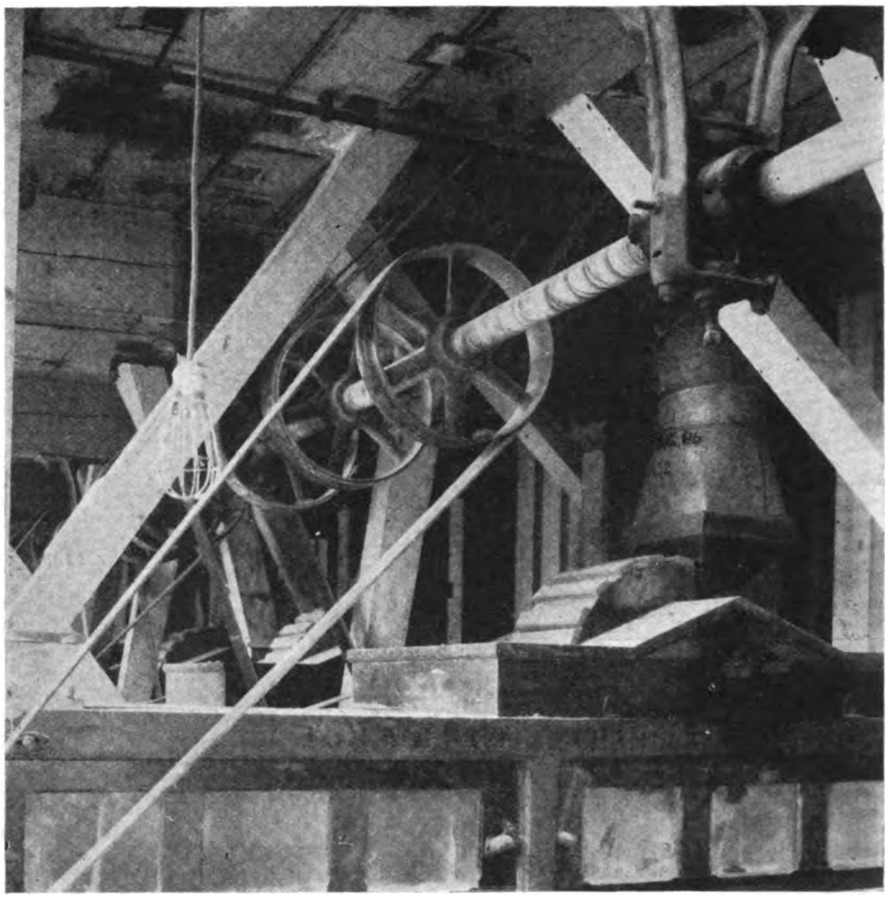
Frequently the necessity of increased capacity, discontinued process, rearrangement of machines served or some such trouble retires a fan from service. In such a case in a large plant, an opportunity to use a belted fan to advantage elsewhere will generally soon occur. Usually, the required speed will be quite different and the service and capacity different. With a belted fan this simply means putting it into service again with a different shop standard size of motor and an appropriate motor pulley. With a direct-connected fan the case is quite different. It is likely to be many years before the same combination of frame size of fan and motor size and speed is needed again.

EFFECTIVE power transmission occupies a more important place in the economical operation of mills and factories than is ordinarily attributed to it. Altogether too often the whole power transmission system is considered o. k. as long as the wheels will turn. However, no unit of the system is carelessness- or neglect-proof, as was brought out in other articles. One of the principal causes of trouble lies in the assumption that, once installed, each unit "stays put" in its relation to the others. In this, shafting, on either line- or countershaft, is perhaps the worst offender and usually gets the least blame, since the trouble backs up into bearings, couplings, belts or chains, or other units. Shafts put in alignment and kept that way go far toward obtaining smooth and economical operation of a shop.

Things to Know About

Line-Shafting and Hangers

When They Are Used as the Backbone of Power Transmission Where the Groups of Machines Are Driven As a Unit



Dust is an important factor in the operation of this installation of roller-bearing hangers in a flour mill.

By FRANK E. GOODING

Associate Editor, Industrial Engineer

IN THE early days water wheels and steam engines supplied the driving force in most plants and were connected to large headshafts by belts or ropes, or in the case of water wheels, sometimes by gearing. These head lineshafts in turn operated several lines of smaller shafting. With the increasing application of motor drives in mills and factories, the single large driving unit has been subdivided into several smaller power units each connected to an individual machine or to line-shafts in turn driving a group of machines. This has eliminated the friction loss of the heavy head shafting and provided a more flexible arrangement as shafts can be driven at an angle or any distance from the main drive unit without difficulty.

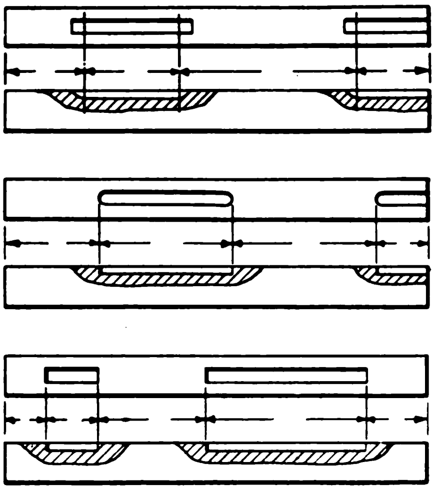
It is not the purpose of this article to discuss relative merits of group and individual drives and the types of work to which they are best adapted. This is taken up in a series of three articles on "When to Use Group and Individual Drives," the first and second of which appeared in the February and March issues of the INDUSTRIAL ENGINEER; the third and last article begins on page 174 of this issue.

Shafting as used in the ordinary industrial plant consists of a round bar of steel turned from a hot-rolled bar. This makes it perfectly round and of a standard diameter so that stock sizes of pulleys, flanges, couplings, clutches, bearings, and other similar mechanical power transmission equipment will fit on it without re-boring them to a gage fit. Also when removed from one shaft they will fit on another of the same dimension. Some old shops use a cold-rolled or drawn steel shafting. Cold-rolled shafting is made, as the name implies, by passing the rough bar cold through various grooves of a finishing rolling mill, which reduces it to the required diameter. Drawn shafting is made by drawing cold bars through dies of the specified diameter. In both types of shafting the diameter and shape is not quite as standard as it is with turned shafting and also a hard shell or scale forms on the surface. When this shell or skin is cut, as is necessary when key seating or doing other machine work, the shaft will bend or spring so that it is almost impossible to straighten it again. Because accuracy in shape, diameter, and straightness, as well as the possibility of cutting keyways without distortion, are some of the most important characteristics of shafting, turned shafting is generally used. However, some old installations of the other types are still in use.

In the manufacture of turned shafting the hot-rolled bars are first straightened and then turned and polished in automatic lathes. Since the bar is hot rolled there is not as much of a strain set up in the skin or shell of the bar, as was the case with cold-rolled or drawn shafting. Because all this thin skin is taken off when the shaft is turned there are no remaining stresses in the shaft to bend it in case a keyway is cut. Also, in case the shaft becomes bent it is more easily straightened again. As these automatic lathes may be set to turn to a standard diameter, the shafting which may be bought from almost any dealer, is a standard size in all cases. However, in the purchase of shafting it is well to check the diameter, allowing for

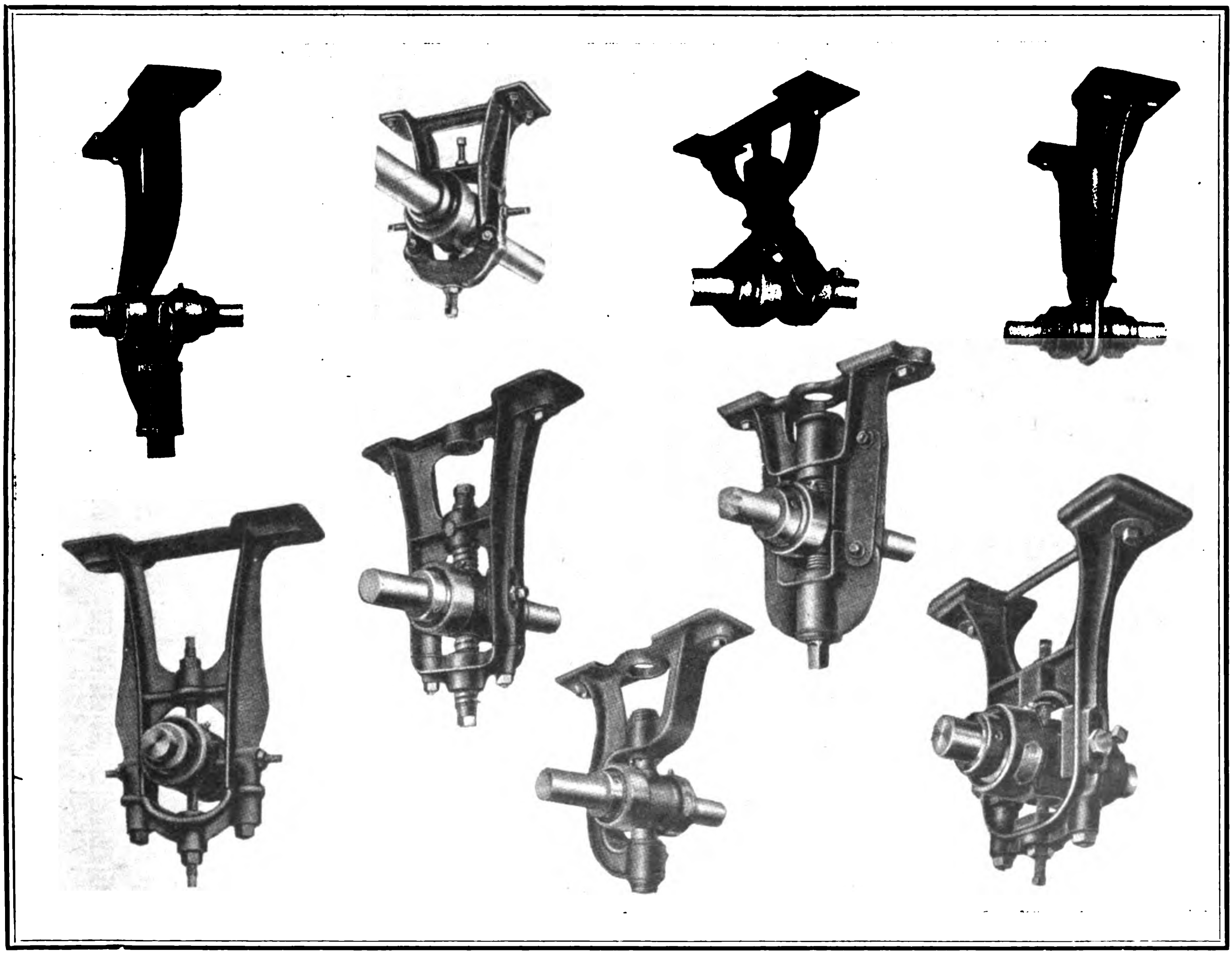
a commercial tolerance of 0.008 in. An extra charge is made where exact size or to within 0.0015 in., or less, over or under, is required. For ordinary lineshaft work an accuracy of this amount is not necessary.

While shafting may be obtained in any diameter, certain sizes have become a commercial standard and in all cases where possible effort should be made to use these standard sizes as they have also become a standard for couplings, clutches, pulleys, and the other mechanical power transmission elements. In most cases an extra charge of about 10 per cent is added to the price of any of this equipment for having it bored to an off-standard size dimension. In addition, there is the difficulty of these mechanical power transmission elements not being interchangeable if of an off-standard size. These standard diameters are the same as shown in the tables on page 180 up to $5\frac{15}{16}$ in. The diameters given above that dimension are special shafts. It will be noticed that in most cases they are $\frac{1}{16}$ under an even inch, half-inch or quarter-inch dimension. For example, one standard shaft size is $2\frac{15}{16}$ inches. In this case, a 3-in. bar is turned down $\frac{1}{16}$ in. To get an even 3-in. turned bar would require the next larger size commercial stock and could be provided, but at an extra expense. Shafting is sold by the pound, and the price fluctuates according to the price of steel. Most manufacturers require that orders for shafting of a special diameter, or if it must be within an extra close tolerance, call for not less than 2,000 lb., as these orders are made up special.



The different types of keyseats which are used in lineshaft work.
When an industrial plant orders the keyways cut before the shafts are delivered they should be careful to specify which type of keyways are required. Unless otherwise specified most manufacturers of lineshafting will cut keyways as in the top illustration, which shows the keyseat with the ends as left by the milling cutter. The middle illustration shows keyseats with round ends and the bottom level. The bottom illustration shows keyseats with square ends and bottom level.

The stock lengths of shafts vary somewhat among the different manufacturers and dealers but ordinarily shafts may be obtained in lengths of 10, 12, 14, 16, 18, 20, 22 and 24 ft. If odd lengths like 17 ft., 19 ft. or 20 ft. 3 in., are required they must be cut from the next standard length of bar, which is in even feet, and the entire bar is charged for, as well as for the cut-



This shows the construction of nine different types of standard lineshaft hangers.
The illustrations show the method of getting two- to four-point adjustment, and also the rigidity of the various types. Each of these installations is fitted with a special dumbbell, double-race, ball-bearing box.

Horsepower Transmitted by Turned Steel Shafting

These three tables show the power which may be transmitted by turned steel shafting under various operating conditions and can be used to check the size of lineshaft required. The figures in these tables of horsepower, in their respective order, are based upon the following formula:

Heavy or main shafting: $0.011 \times d^3 \times N$
Shafting carrying gears: $0.014 \times d^3 \times N$
Light shafts carrying pulleys only: $0.018 \times d^3 \times N$
d = *Diameter of shaft*
N = *Number of rev. per minute*

In computing these tables the torsional strength allowed in using the above formula is 3,530 lb., 4,490 lb., and 5,770 lb. respectively. The line of figures in the column for 1 r.p.m. gives the horsepower transmitted by any of the given sizes of shafts at a speed of 1 r.p.m. The horsepower at any other speed can be ascertained by multiplying the horsepower at 1 r.p.m. by the number of r.p.m. desired. In case it should be desired to know the amount of power transmitted by any size of lineshaft at a greater speed than is shown by the table, divide the desired speed by 10 to reduce it to a speed as shown in the table. Then multiply the power shown in the table for the speed reduced by 10 and it will show the power at the desired speed. For example, on a shaft running 800 r.p.m., what power will be transmitted by a $3\frac{3}{16}$*-in. heavy shaft? Dividing 800 r.p.m. by 10 gives 80 r.p.m. A* $3\frac{3}{16}$*-in. shaft running 80 r.p.m. will transmit 28.5 hp., according to the table. Multiplying by 10 gives 285 horsepower. This can be safely transmitted by a* $3\frac{3}{16}$*-in. shaft running at 800 r.p.m., if properly installed and supported.*

It is sometimes necessary to make additional allowance for power transmitted in case shock load, such as punch presses, or shears, or machines operated by clutches, is a part of the line. In such cases, it is customary to increase the horsepower assumed as required for operating the equipment in some cases as much as two or three times to take care of this additional loading.

Revolutions Per Minute	DIAMETER OF SHAFT									
	15/16	1 3/16	1 7/16	1 11/16	1 15/16	2 3/16	2 7/16	2 11/16	2 15/16	3 3/16
1	.0091 .0115 .0148	.0184 .0235 .0302	.0330 .0416 .0535	.0530 .0670 .0860	.0800 .1020 .1310	.1150 .1470 .1880	.1590 .2030 .2610	.2140 .2720 .3500	.2790 .3550 .4560	.3560 .4530 .5830
20	.18 .23 .30	.37 .50 .60	.65 .83 1.07	1.1 1.4 1.7	1.6 2.0 2.6	2.3 2.9 3.8	3.2 4.1 5.2	4.3 5.4 7.0	5.6 7.1 9.1	7.1 9.1 11.7
40	.36 .46 .59	.73 .94 1.21	1.3 1.7 2.1	2.1 2.7 3.5	3.2 4.1 5.2	4.6 5.9 7.5	6.4 8.1 10.4	8.5 10.9 14.0	11.2 14.2 18.2	14.2 18.1 23.3
60	.54 .69 .89	1.1 1.4 1.8	2.0 2.5 3.2	3.2 4.0 5.2	4.8 6.1 7.9	6.9 8.8 11.3	9.6 12.2 15.6	12.8 16.3 21.0	16.7 21.3 27.4	21.4 27.2 35.0
80	.73 .92 1.19	1.5 2.0 2.4	2.6 3.3 4.3	4.2 5.4 6.9	6.4 8.2 10.5	9.2 11.7 15.1	12.7 16.2 20.9	17.1 21.8 28.0	22.3 28.4 36.5	28.5 36.2 46.6
100	.91 1.15 1.48	1.8 2.3 3.0	3.3 4.2 5.4	5.3 6.7 8.7	8.0 10.2 13.1	11.5 14.7 18.8	15.9 20.3 26.1	21.4 27.2 34.9	27.9 35.5 45.6	35.6 45.3 58.3
120	1.1 1.4 1.8	2.2 2.8 3.6	3.9 5.0 6.4	6.3 8.1 10.4	9.6 12.2 15.7	13.8 17.6 22.6	19.1 24.3 31.3	25.6 32.6 41.9	33.5 42.6 54.7	42.7 54.4 70.0
140	1.3 1.6 2.1	2.6 3.3 4.2	4.6 5.8 7.5	7.4 9.4 12.1	11.2 14.3 18.3	16.1 20.5 26.4	22.3 28.4 36.5	29.9 38.1 48.9	39.1 49.7 63.8	49.8 63.4 81.6
160	1.5 1.9 2.4	3.0 3.8 4.8	5.2 6.7 8.6	8.5 10.8 13.8	12.8 16.3 21.0	18.4 23.5 30.1	25.5 32.4 41.7	34.2 43.5 55.9	44.6 56.8 73.0	57.0 72.5 93.3
180	1.6 2.1 2.7	3.3 4.2 5.4	5.9 7.5 9.6	9.5 12.1 15.6	14.4 18.3 23.6	20.7 26.4 33.9	28.7 36.5 46.9	38.4 49.0 62.9	50.3 63.9 82.1	64.1 81.5 104.9
200	1.8 2.3 3.0	3.7 4.7 6.0	6.5 8.3 10.7	10.7 13.5 17.3	16.0 20.4 26.2	23.0 29.3 37.7	31.9 40.6 52.1	42.7 54.4 69.9	55.8 71.0 91.2	71.2 90.6 116.6
210	1.9 2.4 3.1	3.9 4.9 6.3	6.9 8.7 11.3	11.2 14.1 18.2	16.8 21.4 27.5	24.2 30.8 39.6	33.5 42.6 54.7	44.8 57.1 73.4	58.6 74.6 95.8	84.8 95.1 122.4
220	2.0 2.5 3.3	4.1 5.2 6.6	7.2 9.2 11.8	11.7 14.8 19.0	17.6 22.4 28.8	25.3 32.2 41.5	35.1 44.6 57.4	47.0 59.8 76.9	61.4 78.1 100.3	88.3 99.7 128.3
230	2.1 2.7 3.4	4.2 5.4 6.9	7.6 9.6 12.3	12.3 15.5 19.9	18.4 23.4 30.1	26.5 33.7 43.3	36.6 46.6 60.0	49.1 62.6 80.4	64.2 81.7 104.9	91.9 104.2 134.1
240	2.2 2.8 3.6	4.4 5.6 7.2	7.8 10.0 12.8	12.8 16.2 20.8	19.2 24.4 31.4	27.6 35.2 45.2	38.2 48.7 62.6	51.2 65.3 83.9	67.0 85.2 109.4	95.4 108.7 139.9
250	2.3 2.9 3.7	4.6 5.9 7.5	8.2 10.4 13.4	13.3 16.8 21.6	20.0 25.5 32.8	28.8 36.6 47.1	39.8 50.7 65.2	53.4 68.0 87.4	69.8 88.8 114.0	99.0 113.3 145.7
260	2.4 3.0 3.9	4.8 6.1 7.8	8.5 10.8 13.9	13.8 17.5 22.5	20.8 26.5 34.1	29.9 38.1 49.0	41.4 52.7 67.8	55.5 70.7 90.8	72.5 92.3 118.6	103. 118. 152.
270	2.5 3.1 4.0	4.9 6.3 8.1	8.8 11.2 14.4	14.4 18.2 23.4	21.6 27.5 35.4	31.1 39.6 50.9	43.0 54.7 70.4	57.7 73.4 94.3	75.3 95.9 123.1	106. 122. 157
280	2.5 3.2 4.2	5.2 6.6 8.4	9.2 11.6 15.0	14.9 18.8 24.2	22.4 28.5 36.7	32.2 41.0 52.8	44.6 56.8 73.0	59.8 76.2 97.8	78.1 99.4 127.7	110. 127. 163.
290	2.6 3.4 4.3	5.3 6.8 8.7	9.5 12.1 15.5	15.4 19.5 25.1	23.2 29.5 38.0	33.4 42.5 54.6	46.2 58.8 75.6	61.9 78.9 101.3	80.9 103.0 132.2	113. 131. 169.
300	2.7 3.5 4.5	5.5 7.0 9.0	9.8 12.5 16.0	16.0 20.2 26.0	24.0 30.5 39.3	34.5 44.0 56.5	47.8 60.8 78.2	64.1 81.6 104.8	83.7 106.5 136.8	117. 136. 175.

Revolutions Per Minute	DIAMETER OF SHAFT									
	3 7/16	3 11/16	3 15/16	4 3/16	4 7/16	4 11/16	4 15/16	5 3/16	5 7/16	5 11/16
1	.4470 .5690 .7310	.5510 .7020 .9020	.6710 .8550 1.1000	.8080 1.0280 1.3220	.961 1.223 1.573	1.133 1.442 1.854	1.324 1.685 2.167	1.535 1.954 2.513	1.768 2.250 2.894	2.023 2.576 3.311
20	8.9 11.4 14.6	11.0 14.0 18.1	13.4 17.1 22.0	16.2 20.6 26.4	19.2 24.5 31.5	22.7 28.8 37.1	26.5 33.7 43.3	30.7 39.1 50.3	35.4 45.0 57.9	40.5 51.5 66.2
40	17.9 22.8 29.2	22.1 28.1 36.1	26.9 34.2 44.0	32.3 41.1 52.9	38.4 48.9 62.9	45.3 57.7 74.2	53.0 67.4 86.7	61.4 78.2 100.5	70.7 90.0 115.7	81.0 103.0 132.4
60	26.8 34.1 43.9	33.1 42.1 54.2	40.3 51.3 66.0	48.5 61.7 79.3	57.7 73.4 94.4	68.0 86.5 111.2	79.5 101.1 130.0	92.1 117.3 151.0	106. 135. 174.	120. 155. 199.
80	35.8 45.5 58.5	44.1 56.2 72.2	53.7 68.4 87.9	64.6 82.2 105.7	76.9 97.8 125.8	90.6 115.3 148.3	106. 135. 173.	123. 156. 201.	142. 180. 232.	162. 206. 265.
100	44.7 56.9 71.1	55.2 70.2 90.3	67.2 85.5 110.0	80.8 102.8 132.2	96.1 122.3 157.3	113. 144. 185.	133. 169. 217.	154. 195. 251.	177. 225. 289.	202. 258. 331.
120	53.6 68.3 87.7	66.2 84.2 108.2	80.6 102.6 131.9	96.9 123.3 158.6	115. 147. 189.	136. 173. 223.	159. 202. 260.	184. 235. 302.	212. 270. 347.	243. 309. 397.
140	62.6 79.7 102.3	77.2 98.3 126.3	94.0 119.6 153.8	113. 144. 185.	135. 171. 220.	159. 202. 260.	186. 236. 303.	215. 274. 352.	248. 315. 405.	283. 361. 464.
160	71.5 91.0 117.0	88.2 112.3 144.4	107. 137. 176.	129. 165. 212.	154. 196. 252.	181. 231. 297.	212. 270. 347.	246. 313. 402.	283. 360. 463.	324. 412. 530.
180	80.5 102.4 131.6	99.3 126.3 162.4	121. 154. 198.	145. 185. 238.	173. 220. 283.	204. 260. 334.	239. 303. 390.	276. 352. 452.	318. 405. 521.	364. 464. 596.
200	89.4 113.8 146.2	110. 140. 181.	134. 171. 220.	162. 206. 264.	192. 245. 314.	227. 288. 371.	265. 337. 433.	307. 391. 503.	354. 450. 579.	405. 515. 662.
210	93.9 119.5 153.5	116. 147. 190.	141. 180. 231.	170. 216. 278.	202. 257. 330.	238. 303. 389.	278. 354. 455.	323. 410. 528.	371. 473. 608.	425. 541. 695.
220	98.3 125.2 160.8	121. 154. 199.	148. 188. 242.	178. 226. 291.	211. 269. 346.	249. 317. 408.	291. 371. 477.	338. 430. 553.	389. 495. 637.	445. 567. 729.
230	103. 131. 168.	127. 161. 208.	154. 197. 253.	186. 236. 304.	221. 281. 362.	261. 332. 426.	305. 388. 499.	353. 450. 578.	407. 518. 666.	466. 592. 762.
240	107. 137. 175.	132. 169. 217.	161. 205. 264.	194. 247. 318.	231. 294. 378.	272. 346. 445.	318. 405. 520.	369. 469. 603.	424. 540. 695.	486. 618. 795.
250	112. 142. 183.	138. 176. 226.	168. 214. 275.	202. 257. 330.	240. 306. 393.	283. 361. 464.	331. 421. 542.	384. 489. 628.	442. 563. 723.	506. 644. 828.
260	116. 148. 190.	143. 183. 235.	175. 222. 286.	210. 267. 344.	250. 318. 409.	295. 375. 482.	344. 438. 564.	399. 508. 653.	460. 585. 752.	526. 670. 861.
270	121. 154. 198.	149. 190. 244.	181. 231. 297.	218. 278. 357.	260. 330. 425.	306. 389. 501.	358. 455. 585.	415. 528. 678.	478. 608. 781.	546. 695. 894.
280	125. 159. 205.	154. 197. 253.	188. 239. 308.	226. 288. 370.	269. 343. 440.	317. 404. 519.	371. 472. 607.	430. 547. 704.	495. 630. 810.	567. 721. 927.
290	130. 165. 212.	160. 204. 262.	195. 248. 319.	234. 298. 383.	279. 355. 456.	329. 418. 538.	384. 489. 629.	445. 567. 729.	513. 653. 839.	568. 747. 960.
300	134. 171. 219.	166. 211. 271.	202. 256. 330.	242. 308. 397.	288. 367. 472.	340. 433. 556.	397. 506. 650.	461. 586. 754.	531. 675. 868.	608. 773. 994.

Revolutions Per Minute	DIAMETER OF SHAFT									
	5 15/16	6½	7	7½	8	8½	9	10	11	12
1	2.302 2.930 3.768	3.02 3.84 4.94	3.77 4.80 6.17	4.64 5.91 7.60	5.63 7.17 9.22	6.76 8.60 11.05	8.02 10.20 13.10	11.00 14.00 18.00	14.64 18.63 23.90	19.00 24.20 31.10
20	46.1 58.6 75.3	60.4 76.9 98.8	75.5 96.0 123.0	92.8 118.0 152.0	113. 143. 184.	135. 172. 223.	160 204. 262.	220. 280. 360.	293. 373. 479.	380. 484. 622.
40	92.1 117.2 150.7	121. 154. 198.	151. 192. 247.	185. 236. 304.	225. 287. 368.	270. 344. 466.	321. 408. 525.	440. 560. 720.	585. 745. 958.	760. 967. 1244.
60	138. 176. 226.	181. 231. 297	226 288. 370.	278. 354. 456.	340. 430. 553.	405. 516. 699.	481. 612. 787.	660. 840. 1080.	878. 1118. 1437.	1140. 1451. 1866.
80	184. 234. 301.	242. 306. 395.	301 384. 494.	371 472. 608.	450. 573. 737.	540. 688. 932.	641. 816. 1049.	880 1120. 1240.	1171. 1490. 1916.	1520. 1935. 2488.
100	230. 293. 377.	302. 384. 494.	377. 480. 617	464 590. 760.	563. 717. 921.	676. 860. 1165.	802. 1020. 1312.	1100. 1400. 1800.	1464. 1863. 2396.	1900. 2419 3110
120	276. 352. 452.	362. 461. 593.	452. 576. 741.	557. 708. 912.	675. 860. 1105.	810. 1032. 1398.	962. 1224. 1574.	1320. 1680. 2160.	1756. 2236. 2875.	2280. 2903. 3732.
140	322. 410. 528.	423 538 692.	528. 672. 864.	649. 826. 1064.	788. 1004. 1289.	945. 1204. 1631.	1123. 1428. 1837.	1540. 1960. 2520.	2049. 2609. 3354.	2660. 3388. 4354.
160	368. 469. 603.	483. 615. 791.	603. 768 988.	742. 944. 1216.	900. 1147. 1473.	1081. 1376. 1864.	1283. 1632. 2099.	1760. 2240. 2880.	2342. 2981. 3833.	3040. 3870. 4976.
180	414. 527. 678.	544. 692. 890.	679. 864. 1111	835 1062. 1368.	1013. 1290. 1658.	1216. 1548. 2097.	1443. 1836. 2361.	1980. 2520. 3240.	2635. 3354 4312.	3420. 4364. 5598.
200	461 586. 754.	604. 769. 988.	755. 960. 1235.	928. 1181. 1520.	1126. 1434. 1842.	1351. 1720. 2330.	1604. 2040. 2624.	2200 2800. 3600.	2928. 3727. 4792.	3800. 4838. 6220.
210	484. 615. 791.	634. 807. 1038.	792. 1008. 1296.	974. 1240. 1596.	1182. 1505. 1934.	1418. 1806. 2446.	1684. 2142. 2755.	2310. 2940. 3780.	3074. 3913. 5031.	3990. 5080. 6531.
220	507. 645. 829.	664. 845. 1087.	830. 1056. 1358.	1020. 1299. 1672.	1238. 1577. 2026.	1486. 1892. 2563.	1764. 2244. 2886.	2420 3080. 3960.	3220. 4100. 5270.	4180. 5322. 6842.
230	530. 674. 867.	695. 884. 1137.	867. 1104. 1420.	1067. 1358. 1748.	1295. 1649. 2118.	1553 1978. 2680.	1845. 2346. 3017.	2530. 3220. 4140.	3367. 4285. 5510.	4370. 5564. 7153.
240	553. 703. 904.	725. 922. 1186.	905. 1152. 1481.	1114. 1417. 1824.	1351. 1720. 2210.	1621. 2064. 2796.	1925. 2448. 3149.	2640. 3360. 4320.	3513. 4472. 5750.	4560. 5806. 7464.
250	576. 733. 942.	755. 961. 1236.	943. 1200. 1543.	1160. 1476. 1900.	1407. 1792. 2302.	1688. 2150. 2912.	2005. 2550. 3280.	2750. 3500. 4500.	3660. 4658. 5990.	4750. 6048. 7775.
260	599. 762. 980.	785. 1000. 1285.	981. 1248. 1605.	1206. 1535. 1976.	1464. 1864. 2394.	1756. 2236. 3029.	2085. 2652. 3411.	2860. 3640. 4680.	3806. 4844. 6229.	4940. 6290. 8086.
270	622. 791. 1017.	815. 1038. 1334.	1018. 1296. 1667.	1252. 1594. 2052.	1520. 1935. 2487.	1824. 2322. 3145.	2185. 2754. 3542.	2970. 3780. 4860.	3952. 5031. 6468.	5130. 6532. 8397.
280	645. 821. 1055.	845. 1076. 1384.	1056. 1344. 1728.	1300. 1653. 2128.	1576. 2007. 2579.	1891. 2408. 3262.	2245. 2856. 3673.	3080. 3920. 5040.	4100. 5217. 6708.	5320. 6773. 8708.
290	668. 850. 1093.	876. 1115. 1433.	1094. 1392. 1790.	1345. 1712. 2204.	1632. 2079. 2671.	1959. 2494. 3378.	2326. 2958. 3805.	3190. 4060. 5220.	4245. 5403. 6948.	5510. 7018. 9019.
300	691. 879. 1130.	906. 1153. 1483.	1132. 1440. 1852.	1392. 1771. 2280.	1689. 2150. 2764.	2026. 2580. 3495.	2406. 3060. 3936.	3300. 4200. 5400.	4392 5590. 7187.	5700. 7257. 9330.

These Articles Contain Other Information on Transmission Equipment

ting. Ordinarily, shafts longer than 22 ft. do not go into an ordinary box car and so there is often some delay in shipping such bars by rail on account of the necessity of providing special cars. Because of the difficulty in handling, the long bars are more often bent in shipment, especially when shafts are shipped with flanges attached.

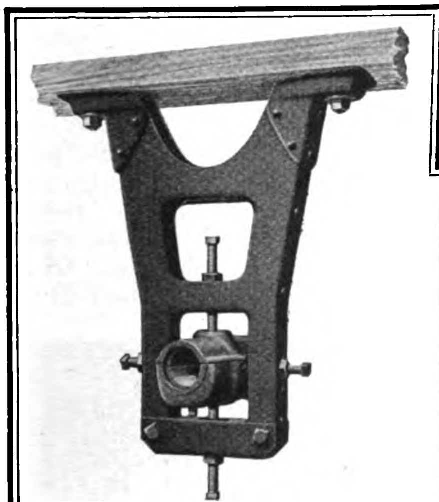
The best length of shaft to use varies somewhat with the way the shaft is to be hung. It is usually best to use a shaft of such length that at least two hangers will be included in each length of shaft. For example, if the hangers are spaced 8 ft. apart a 16-ft. shaft would be used, while if spaced 10 ft. apart, a 20-ft. shaft would be required. Shafts can be obtained up to 40 ft. on special order and at an extra price.

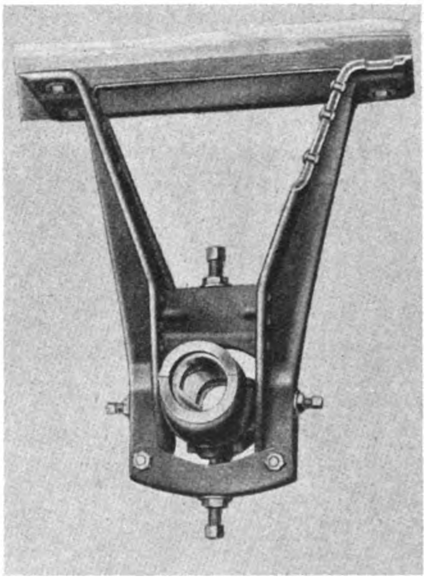
The stresses to which lineshafting are mainly subject are, torsion or twisting, and transverse or bending stresses. The torsional strength or resistance to breaking by twisting is directly proportional to the cube of the diameter of the shaft. The torsional stiffness which determines the angle through which the shaft is twisted varies directly as the fourth power of the diameter and inversely as the length of the shaft.

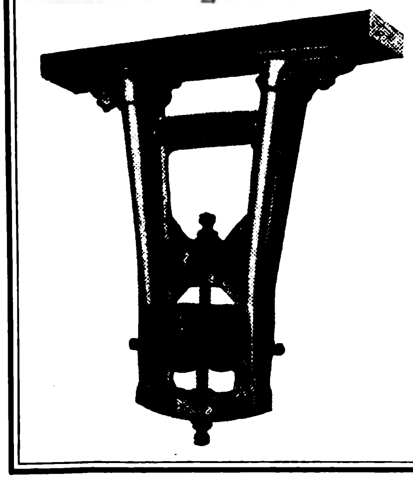
The transverse strength or resistance to bending as a beam is directly proportional to the cube of the diameter and inversely proportional to the length between supports or bearings. The transverse stiffness which determines the deflection or bending of the shaft, considered as a beam, is directly proportional to the fourth power of the diameter, and is inversely proportional to the load and to the cube of the distance between the supports.

It is a somewhat complicated problem to work out mathematically the exact size of a lineshaft. The accompanying tables, however, show the power which may be transmitted by a lineshaft under three classes of service. In general the speed of the shaft is determined in advance by operating conditions. In determining the load on a shaft, care must be exercised to see that proper allowance is made for shock loads and clutches.

Also, one of the practical difficulties in industrial installations lies in the fact that due to the frequent changes, rearrangements and the addition of machines it is always best to provide a shaft of at least slightly above absolutely required size so that it would always be able to take care of these additions or changes. In the arrangement of machines, wherever possible, it is best to provide the heaviest load, and particularly machines which give a shock load, as near as possible to the driving mechanism so that the twisting or torsion load of the shock will not be transmitted







Three types of pressed-steel shaft hangers.

Pressed-steel hangers, because of their lightness, are being used in many light and ordinary installations of power transmission service. The cut-away view shows how one type of hanger is reinforced.

Recommended Sizes for Shafting Key-Stock

Shaft Diameters (Inches) Over – To and including	Key Nominal Sizes (Inches) Square Keys W × T	Key Nominal Sizes (Inches) Flat Keys W × T	Key-Stock Sizes (Inches) Square, Minimum Width S	Square and Flat, Minimum Thickness S	Square and Flat, Minimum Thickness F	Tolerances	Square, Maximum Width S	Square and Flat, Maximum Thickness S	Square and Flat, Maximum Thickness F
7/16 – 11/16	1/8	1/8 × 3/32	0.123	0.123	0.092	−0.0020	0.125	0.125	0.094
11/16 – 7/8	3/16	3/16 × 5/32	0.185	0.185	0.154	−0.0020	0.1875	0.1875	0.156
7/8 – 1 5/16	1/4	1/4 × 3/16	0.248	0.248	0.185	−0.0020	0.250	0.250	0.1875
1 5/16 – 1 3/8	5/16	5/16 × 3/16	0.310	0.310	0.185	−0.0020	0.3125	0.3125	0.1875
1 3/8 – 1 11/16	3/8	3/8 × 1/4	0.373	0.373	0.248	−0.0020	0.375	0.375	0.250
1 11/16 – 1 7/8	7/16	7/16 × 5/16	0.435	0.435	0.310	−0.0025	0.4375	0.4375	0.3125
1 7/8 – 2 1/4	1/2	1/2 × 3/8	0.497	0.497	0.373	−0.0025	0.500	0.500	0.375
2 1/4 – 2 3/4	5/8	5/8 × 7/16	0.622	0.622	0.435	−0.0025	0.625	0.625	0.4375
2 3/4 – 3 1/4	3/4	3/4 × 1/2	0.747	0.747	0.497	−0.0025	0.750	0.750	0.500
3 1/4 – 3 3/4	7/8	7/8 × 5/8	0.872	0.872	0.622	−0.0030	0.875	0.875	0.625
3 3/4 – 4 1/2	1	1 × 3/4	0.997	0.997	0.747	−0.0030	1.000	1.000	0.750
4 1/2 – 5 1/2	1 1/4	1 1/4 × 7/8	1.247	1.247	0.872	−0.0030	1.250	1.250	0.875
5 1/2 – 6	1 1/2	1 1/2 × 1	1.497	1.497	0.997	−0.0030	1.500	1.500	1.000

Key sizes for lineshaft work.
The above table shows the recommendation made by the American Society of Mechanical Engineers as to standard sizes for various shaft diameters. These recommendations are out for comment and have not as yet been adopted.

through a long length of shafting. A driving unit at one end and a shock load at the other will result in an uneven transmission of power which is made obvious by the whipping action of belts.

Forged and Special Alloy Shafts for Special Requirements

The largest common commercial size of turned steel shafting is $5^{15}/_{16}$ in. in diameter. Shafts 6 in. or larger are usually made of special forgings. These are made by working an ingot of steel under a steam hammer to a diameter somewhat larger than necessary and then turning it down to an exact diameter in the lathe. In this way, a much stronger shaft is obtained. Also, sections of the forged shafting may be left larger in diameter than other parts. These are made on special order and to dimensions.

Where extra strength, shock resistance, and other unusual requirements are needed for a special installation, nickel steel or vanadium steel shafts are frequently installed. However, the ordinary industrial installation would not require either of these shafts.

Quills or hollow shafts are made from forgings which are later bored out. A quill is used where an extra heavy pulley, sheave or gear is to be installed loose on a line of shafting and connected with a clutch. The advantage of the quill is that the entire weight of this sheave, pulley or gear is supported on the hollow shafting by its own bearing and does not add to the bending load of the lineshaft when it is either idle or running.

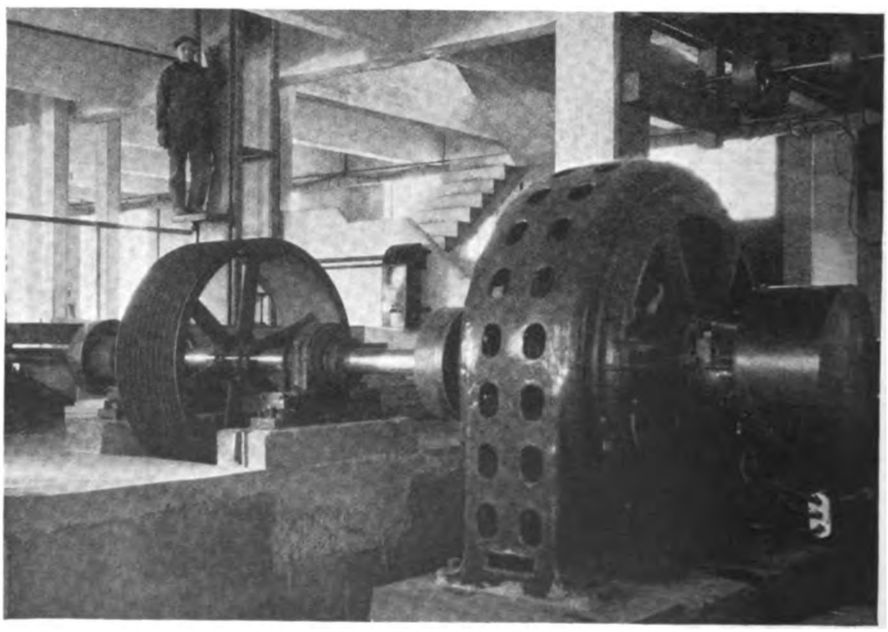
Previous articles which have appeared in INDUSTRIAL ENGINEER, as listed in the box on page 181, have discussed the major mechanical elements of power transmission excepting the shafting, hangers, and bearings. Of these, the two latter are intimately connected with the two most important considerations in lineshaft construction and operation—alignment and friction loss.

Some of the Devices Employed for Supporting Lineshafts

In general, hangers differ largely in design according to the purpose for which they are to be used. For example the most common types are: Drop hangers for suspending from the ceiling, floor stands for attaching shafting to the floor, and extensions for post hangers to support the line of shafting at a fixed distance from the wall or from posts. The drop of the hanger—the distance from the base of the hanger to the center of the shaft—often determines the size of pulley which can be used. This, however, depends upon the construction of the building. Frequently drop hangers are used as floor hangers merely by fastening to the floor and inverting the bearings.

An important point in industrial lineshaft construction is to provide sufficient means for adjustment of the shaft. Hangers ordinarily are made with either two- or four-point adjustment, as may be seen from the accompanying illustrations. Four-point, or universal adjustment, gives the greatest opportunity for aligning shafting without having to move the base of the hanger and is being used largely for industrial installations. Two-point adjustment hangers are used for short shafts and for light and comparatively low speed work or for countershafts. To get side adjustment it is necessary to slip the hanger in the slotted base. Obviously it would be more difficult to line up a long shaft and particularly to realign it after it had been used or a building has settled.

Ordinarily, hangers are placed about 8 or 10 ft. apart, depending upon the load and upon the service. Large diameter pulleys, heavy or shock loads, or a heavily loaded pulley, as the driving pulley, often require an extra hanger or closer spacing. Hangers should be close enough to prevent the load from springing (*Continued on page 211*)



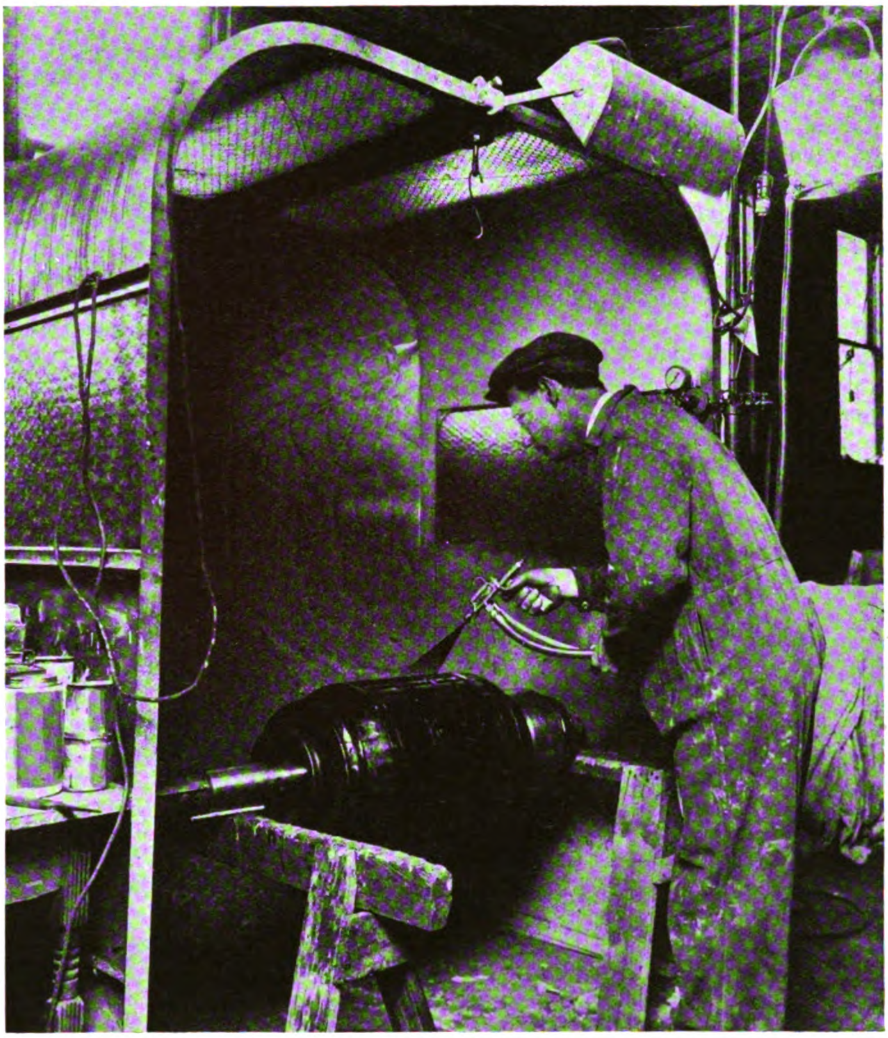
Here self-aligning, ball-bearing pillow blocks are installed on each side of a 5-ft. rope sheave. This is connected to a 350-hp. motor by a 6-in. shaft operating at 250 r.p.m.
The pillow blocks are on wedge adjustment plates which provide for up-and-down adjustment. Side adjustments are obtained by screws. Pillow blocks are used on heavy drives and also on many machines.

GOOD INSULATING RESULTS can be easily secured when varnish is given a fair chance on the surfaces to which it is applied. Dirt and lack of care in application are the two things that always cause trouble. On these points Mr. Hazeltine says: Dirty equipment ruins insulation quite as quickly as does faulty application. Wash your brushes or air spray as soon as you are through using them. Clean the varnish tank and strain the varnish at regular intervals. Dirt breeds trouble. Keep your varnish room and apparatus clean.

Suggestions When

Applying Insulating Varnishes

By the Dipping and Baking, Brush and Spraying Or by Vacuum Impregnation Methods



Spraying varnish is preferable to brushing for the finishing application. When ovens are not available it is good practice to dry the coils by passing current through the windings. Oven drying is better, however. The spray-gun shown is made by the De Vilbiss Manufacturing Co., Toledo, Ohio.

By H. L. HAZELTINE
Engineer of Insulation, The Sterling Varnish Co., Pittsburgh, Pa.

IN THE ARTICLE that appeared in the March issue of INDUSTRIAL ENGINEER, the writer described insulating varnishes in very general terms. In this article the shop equipment necessary for the proper application of these materials will be taken up before going into the detailed methods for securing specific results, in the articles to follow in this series.

Insulating varnishes may be applied by three general methods which, for convenience, will be termed the dipping and baking method, the brushing and spraying method, or the vacuum pressure impregnating method. No matter which method is followed it is important that the apparatus and the surface to which the varnish is applied should be kept very clean. Oily matter or dirt will ruin even the best of insulation.

Perhaps it will be easier to understand the nature of the equipment required if we fix our attention on a coil as it passes through the various processes and describe the apparatus as we go along.

APPLICATION OF VARNISH BY DIPPING AND BAKING

The best method of applying insulating varnish is by dipping. The main equipment required for this is a dipping tank and a baking oven. As originally wound, the coil contains a considerable amount of air and moisture which prevents the complete filling with varnish. Hence it should be thoroughly dried in an oven in order to drive out all this moisture and occluded air. The same oven may be used for this preheating period as will be described later for the baking period. The time required for this drying will vary from 1 hr. for coils of small cross section to 24 hrs. for large complete armatures and coils composed of a great many turns of very fine wire.

After preheating, the work is taken directly from the oven and dipped, while still hot, in a tank of varnish and allowed to remain until the varnish has thoroughly permeated the inner layers. As the coil cools, the air remaining in the inside, being rarified, contracts and, assisted by the atmospheric pressure on the surface of the tank, draws the varnish into the interior where insulation and binding strength are most needed.

The Dipping Tank—For this work a tank to hold the varnish will be required of such size and shape that the largest piece to be treated can be completely submerged. It should also be of such capacity that the varnish will not become overheated due to the dipping of hot coils with a consequent loss of solvent. This tank can readily be built in any machine shop, with ⅛-in. steel sheets, which are plenty heavy enough. Do not use a zinc-lined tank because

the zinc has a deleterious effect upon varnish materials. A close fitting cover should be provided when the tank is not in use in order to exclude as much air as possible from the varnish and thus keep the solvent from evaporating. A tank suitable for small-size coils is shown in Fig. 1. Note the groove into which the cover fits. This may be filled with some liquid material such as linseed oil, so as to provide a perfect air seal, which will not evaporate readily and which will not harm the varnish should a few drops be spilled into the tank.

Large tanks should be fitted with similar covers. When they are of such size that they cannot be handled easily they should be equipped with some means for drawing off the varnish so as to facilitate cleaning. It is surprising how much dirt will collect in a short space of time and how much trouble can be traced directly to varnish that has become fouled as a result. It is impossible to over-emphasize the absolute necessity of frequent thorough cleaning of both varnish and tank.

As the foreign matter which collects in the tank soon becomes mixed with the varnish it is advisable, when the tank has been emptied and cleaned, to strain the varnish through several thicknesses of cambric before replacing it. This will remove all dirt, partially oxidized varnish and pieces of insulation.

Draining—When you are sure that the coils have absorbed all the varnish possible, they should be slowly withdrawn at about the same rate as that at which the varnish flows from the coils of its own accord under the influence of gravity and capillary attraction. This gives a good uniform covering with the least accumulation possible on the one end. When a sufficient number of coils are treated to warrant its use a machine such as is shown in Fig. 2 will be found very useful. The quicker the dip and the faster the rate of withdrawal, the heavier will be the outside coat and the less will be the penetration.

The coil should be allowed to drain for a sufficient period to allow all dripping to cease and for the varnish to partially "set." The time required will again depend upon the size of the coil and the nature of the

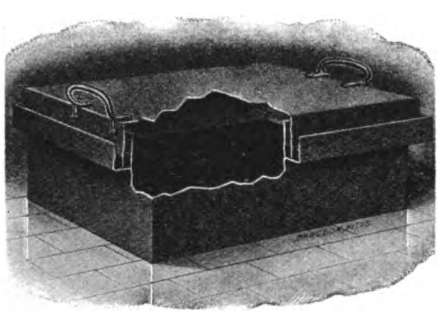


Fig. 1—Dipping tank suitable for small sizes of coils.

Note the groove in which the cover fits, that can be filled with a liquid like linseed oil to provide an air seal.

varnish. When a considerable number of coils are to be treated it is impossible to carry on the entire draining over the tank. Hence it is wise to provide dripping boards over which the coils may be hung, sloped in such a way as to convey the excess varnish back into the tank.

After draining the work should be placed in the oven to bake. It is wise, where possible, to reverse the position of the coil so that the top during draining is at the bottom during baking. The first effect of heat on the partially "set" varnish is to cause it to flow. Hence by reversing the position the heavy accumulation acquired during the draining softens and flows toward the lower end, thus giving a more uniform and pleasing appearance to the finished piece.

The Baking Oven.—The oven required for preheating and baking may be purchased complete from an oven manufacturer, or may be built in the shop. In either case the following suggestions may be helpful.

The outside walls may be constructed of any kind of material desired. It goes without saying that they should be well heat insulated, since the object is to heat the contents of the oven rather than the outside room; an uninsulated surface may be the cause of cold spots and may absolutely prevent an even distribution of temperature throughout the interior of the oven. It is wise, therefore, to build these walls double, filling the air space between

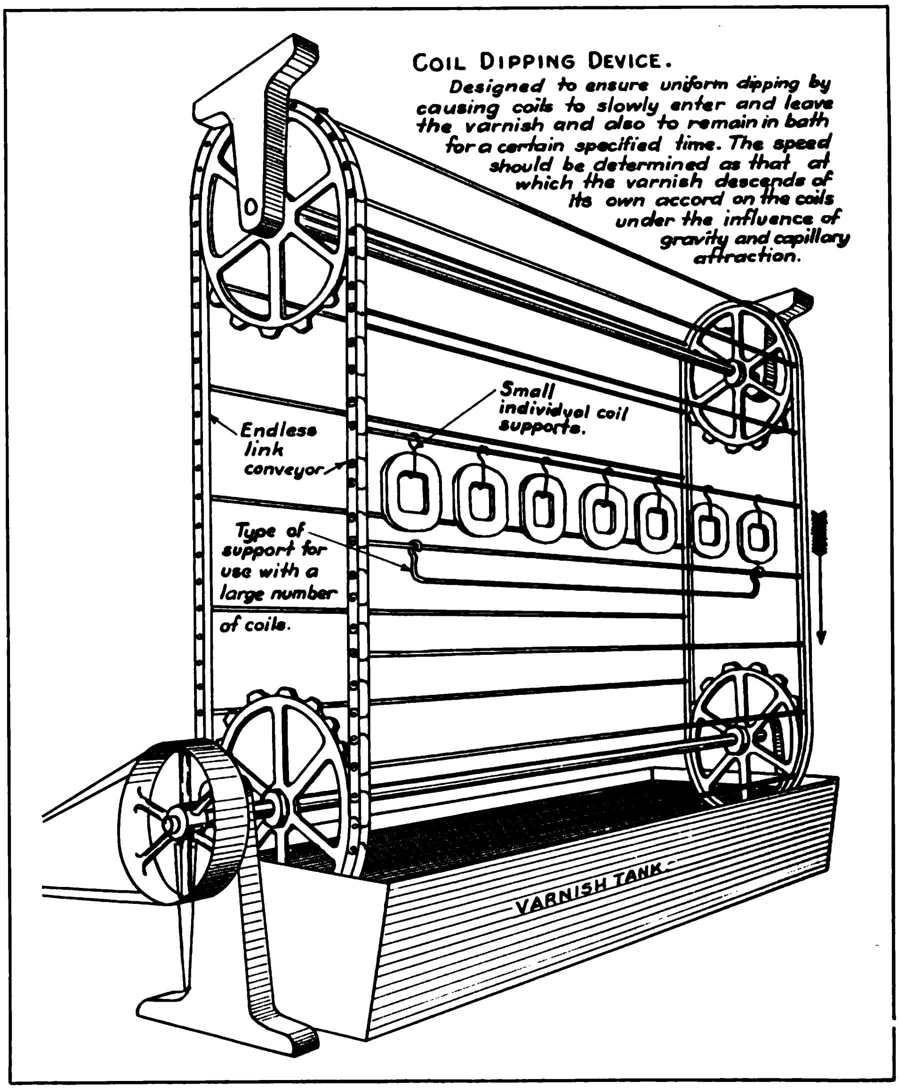


Fig. 2—Coil dipping machine for use where a large number of coils are treated.

with some loose fibrous material that will serve to break up convection currents in the air and thus prevent the passage of heat from the inner to the outer surface. Further protection may be obtained by completely covering the outer surface with some heat-insulating material. It makes little difference what this material is so long as it is remembered that the less heat that escapes into the room the greater will be the saving in fuel and the more uniform the heat inside.

Many sources of heat may be employed. Those in most common use are gas, steam, oil and electricity. Any one of them will give excellent results provided the oven is properly installed. Indirect or radiant heat is the best.

Gas has the advantage of cheapness. Great care must, however, be taken to see that the burners are so installed that the fumes are conveyed to the chimney without entering the oven where they will come in direct contact with the work. These exhaust fumes tend to combine with the varnish and prevent its baking properly.

Steam is the most satisfactory for baking temperatures up to 300 deg. F. because of its easy regulation and control, its almost universal use for other purposes about the shop and the absence of fire risk.

Oil systems are not in such common use as are the other three. The advantages are much the same as those for steam, with the addition of the ability to obtain very high temperatures without the risk attendant upon the carrying of high steam pressures. The same care must be taken in the installation of the burners as is exercised in the case of gas.

Electric ovens are very efficient and probably the easiest to control. Unless properly built they may be expensive to operate, especially when power is purchased.

Whichever form of heat is chosen great care must be taken in placing the heating units so that they will not interfere with the arrangement of the work in the oven, and so that the temperature will be uniform throughout. Since heated air rises, the heating units should be placed close to the floor so that the bottom part of the oven will have the same temperature as the top. Effective positions are either along the sides or underneath a false bottom. A sufficient amount of radiating surface must be provided so that the temperature required will be reached in the shortest time possible, and thereafter maintained without variation. In very large ovens it is sometimes advisable to install a fan in order to keep the air in motion and prevent the collection of cold pockets.

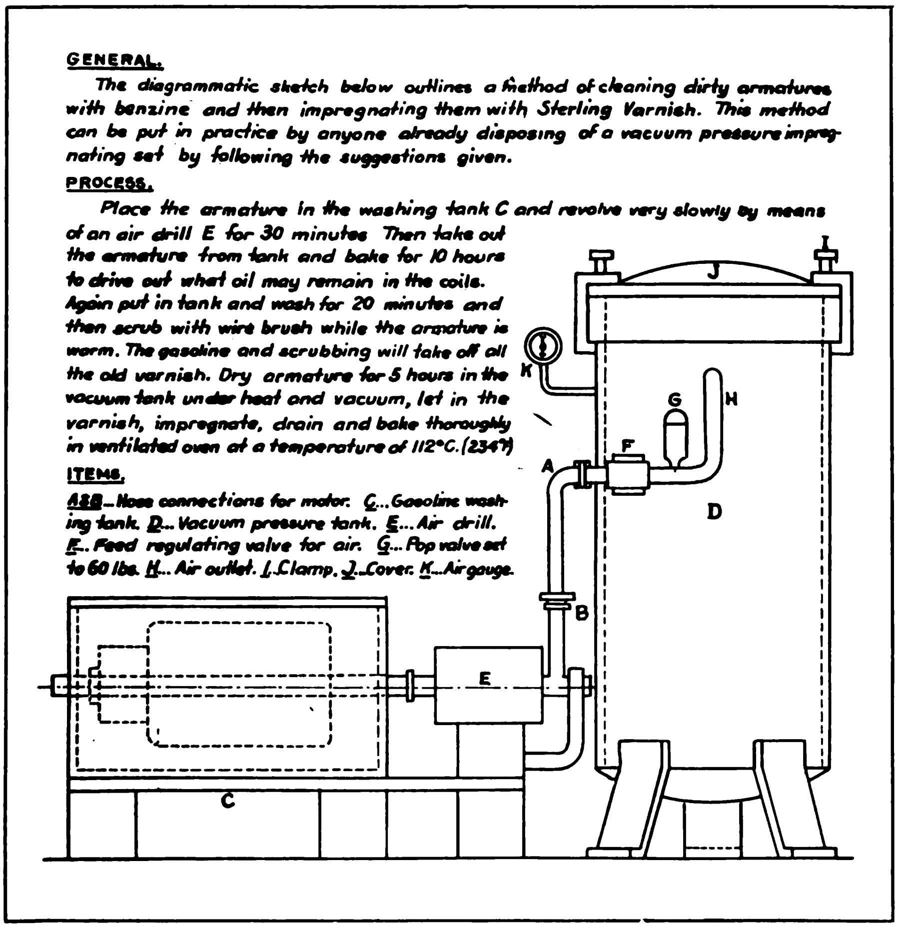
No matter how efficient the heating system, proper drying of the varnish cannot be accomplished as long as it is stewing in the vapor from its own solvent. Hence some means must be used to remove these vapors. In small ovens a direct connection, provided with a damper, to a chimney or a stack is all that is necessary. In large ovens, or those overcrowded with work, forced draft is sometimes required. If, when the doors of the oven are thrown open, a cloud of black smoke pours out into the room, it is evident that you are not carrying away the solvent vapors rapidly enough.

Most baking varnishes are of the oxidizing class and hence a considerable supply of fresh, clean air must always be available. The amount required will depend upon the quantity of work in the oven and the nature of the varnish used. It is better to have too much fresh air than too little. Too much will of course waste the heat, but it is better to do this than to have the varnish only partially dry. It is best to arrange the fresh air inlets in such a position that the entering air strikes the heating units first, so as not to lower the temperature. In small ovens holes drilled through the outside walls will be sufficient. In large ones the blower used to drive the fumes out of the stack may be arranged to draw fresh air into the oven.

Since, in the drying of varnish, the first action of the heat is to drive off the solvent, the damper in the stack should be kept wide open during the initial drying period so as to remove the vapors as quickly as possible. During the later part of the baking, when the solvent has been entirely driven out and the varnish is merely oxidizing, the damper may be partially closed. Care should be taken, however, that it is not shut so tightly that it interferes with the drawing in of the fresh air.

It is important that the temperature of the oven may be known at

Fig. 3—Outfit for cleaning armatures and impregnating them with varnish.



any instant. An oven thermometer should therefore be installed. A recording instrument is very convenient for this purpose as then a complete record of the temperature at all times may be obtained. The thermometer bulb should be so placed that the average temperature throughout the oven will be indicated. The proper position may be determined from comparative readings taken in different sections.

Insulating varnishes may be baked at any temperature desired that will not injure the fibrous insulation. The customary range is from 212 deg. F. to 275 deg. F. Of course, the higher the temperature the quicker the drying of the varnish. The lower temperatures have the advantage of drying the varnish all the way through without the formation of a skin over the outside, which tends to retain some of the varnish in a liquid or semi-liquid state. The high temperatures, however, may be used advantageously during the later period of the baking as this not only shortens the drying period but also tends to give a much harder, stronger surface. In preheating the coils it is best, however, to use not over 220 deg. F. The higher temperature is not needed to drive out the moisture and tends to evaporate too much of the solvent in the varnish when the coils are dipped hot.

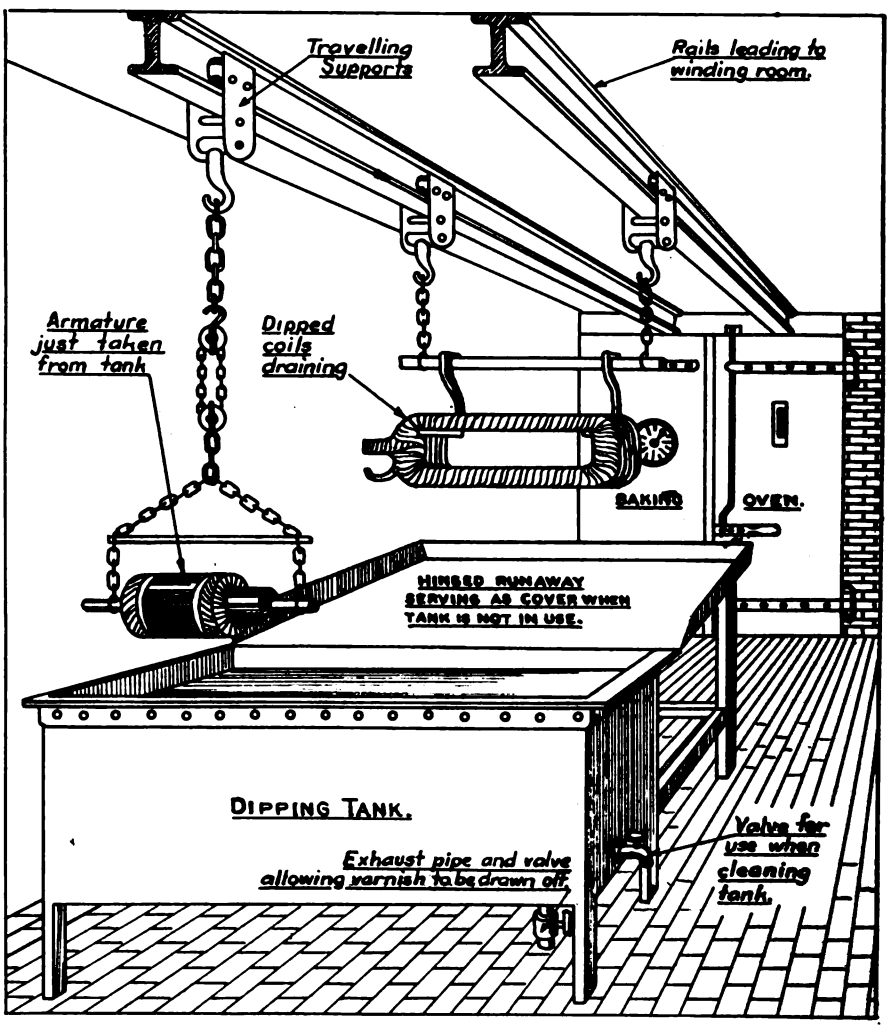
When lack of space prevents the installation of such baking arrangements as have been described, an individual oven may be built. This can be made of a metal box suitably heat insulated and having no bottom. Holes drilled in the top will provide for ventilation and the escape of solvent fumes. Electric heaters fastened to the sides will provide a uniform heat. The coil after treatment may then be laid on the floor, the box placed over it, and the electric heaters connected to the nearest lighting plug.

Apparatus for Cleaning Repair Work—When motor armatures and field coils are brought in for repairs of any kind where complete rewinding is unnecessary, it is the custom in many shops to immerse them in a baking insulating varnish before they are put back into service. This is excellent practice, especially when the motors are subjected to severe conditions or heavy overloads. The varnish penetrates the slot and when dry holds the armature coils in place, even when the insulation has dried out so much in service that they are quite loose. All cracks are filled up thus preventing the entrance of dirt and moisture. Loose laminations are sealed and their vibration prevented. A rust-proof coating is formed over all iron parts. A smooth, dense insulating surface is formed on coils and on creepage surfaces. Vital parts which have been bruised in handling or in which the insulation has been cracked by strains in service or assembly will be completely restored to good condition. The glossy surface produced will prevent the action of water, etc., where the field-coils are connected and taped and will allow dirt to be periodically blown off with an air blast.

These armatures and coils are generally very dusty and oftentimes covered with oil when they are brought in. This accumulation must be removed before the parts are dipped in order not to foul the varnish, and also in order that the varnish may adhere to the surfaces. If dust alone is present it may be removed by blowing with compressed air. A good arrangement is to fit up a closed box so that the armature or coil may be placed inside and an air hose connected near the bottom so as to blow the compressed air into the box. From the top there should be a pipe connecting with the outside air so that the dust and dirt will be blown directly outdoors without entering the room.

If there is considerable grease or oil on the coils it can best be removed by washing in gasoline or benzine. Apparatus suitable for this work is pictured in Fig. 3. The operation is as follows: Place the armature in the oven and bake for 10 hr. or until the coils and core are warmed clear through. Remove from the oven and place in the washing tank *C* filled with gasoline, and revolve very slowly by means of an air control or electric motor *E* for 30 min. This will remove most of the dirt and oil. It would be wise after this process to bake the armature again in order to drive out the gasoline (*Continued on page 209*)

Fig. 4—Dripping, draining and baking arrangements for coils and armatures in a small shop.



Handy Tables For Use When

Changing A. C. Windings for Different Frequencies

And the Practical Ways to Make Such Changes For the Original Speed and Horsepower or for a Different Speed and Horsepower

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QUITE OFTEN it is desired to operate an induction motor on a different frequency than the one for which the motor was originally designed. The following questions then arise: (1) What effect will the new frequency have on the operation of the motor? (2) What changes, if any, are required in the motor windings to insure satisfactory operation on the new frequency? In this article Mr. Roe has worked out in detail the steps to be taken in making various frequency changes and compiled tables that will be useful in this connection.

WHEN changing an induction motor to adapt a design of one frequency for operation on another, mistakes are often made that show up in a change of speed and horsepower that are not suitable for the drive on which the motor is to be used. In this article the writer has listed the practicable changes that can be made and has worked out some examples to show how to make the different changes and secure the desired results. Use is made of tables that the writer has found very convenient in such work.

To begin with, the frequency directly affects the speed of the motor as shown in Table I, which gives the synchronous r.p.m. with different numbers of poles and various cycles. The majority of changes made are from 25 to 60 cycles, 50 to 60, 40 to 60 or *vice versa.* On consulting Table I we find that the no-load speed of a four-pole motor is 750 for 25 cycles, 900 for 30, 1,200 for 40, 1,500 for 50 and 1,800 for 60 cycles. Raising the frequency, therefore, increases the speed in direct proportion and lowering the frequency decreases the speed.

For any frequency changes, the first question to answer is: What will be the speed of the motor on the new frequency and will the resulting speed be satisfactory for the application? As an example, assume that it is desired to change a four-pole, 40-cycle motor for 60-cycle operation. Table I shows the four-pole, 40-cycle speed as 1,200 r.p.m., and the corresponding four-pole, 60-cycle speed as 1,800 r.p.m. Since this is a direct-connected job, the r.p.m. must be kept constant. Therefore, the motor must be rewound for six poles, 1,200 r.p.m. on 60 cycles.

A change in frequency changes the speed in the following proportion: $C \div F = S \div R$ or $R = FS \div C$, where the old frequency equals C, new frequency equals F, old r.p.m. equals S and new speed equals R. Since the windings of an induction motor can be considered the same as in a generator, it follows that the change in speed occasioned by a change in frequency will also affect the line voltage; that is, when a motor is operated at a higher speed higher voltage is required. Likewise, when operated at a lower speed a lower line voltage is required. The voltage then should be varied according to the formula:

$V = FE \div C$, where F and C have the same value as above, E is the old line voltage and V the new line voltage. From this it follows that either the line voltage must be varied in the same proportion and direction as the change in frequency or that the turns per phase or coil must be varied in the same proportion but in the opposite direction to the change in frequency. As an example, consider a 30-cycle, 220-volt, 4-pole, 900-r.p.m. motor that is to be operated on 60 cycles. The new r.p.m. would be 1,800 and the line voltage should be 440 volts, but if it is desired to operate the motor on 220 volts, at 60 cycles, the total turns would have to be reduced one-half.

Another item affected is the horsepower rating of the motor, as Hp. $= (T \times \text{r.p.m.}) \div 5{,}252$, where T equals the torque at one foot radius. If the voltage or turns are varied in the proper amount and direction, the torque will remain practically constant and the horsepower will vary directly as the speed in r.p.m.

From the above remarks, we can now set down the different combinations of changes that are possible.

Change No. 1—With a change in cycles and the line voltage adjusted, the hp. and r.p.m. will vary directly as the frequency and in the same direction.

Table I—Synchronous Speeds With Different Numbers of Poles and Cycles

Number of Poles	Cycles				
	25	30	40	50	60
2	1,500	1,800	2,400	3,000	3,600
4	750	900	1,200	1,500	1,800
6	500	600	800	1,000	1,200
8	375	450	600	750	900
10	300	360	480	600	720
12	250	300	400	500	600
14	214	257	343	428	515
16	187	225	300	375	450
18	166	200	266	333	400
20	150	180	240	300	360
22	136	164	218	273	328
24	125	150	200	250	300
26	115	138	185	230	277
28	107	128	171	214	257
30	100	120	160	200	240
32	94	112	150	187	225
34	88	106	141	176	212
36	83	100	133	166	200

Table II—Multipliers to Use When Raising the Operating Frequency, the Horsepower Varying With the Speed.

Required Change in Cycles	R.P.M.	Hp.	Line Voltage	Circ. Mils.	Turns
25 to 30	1.2	1.2	1.2	1.2	.833
25 to 40	1.6	1.6	1.6	1.6	.625
25 to 50	2.0	2.0	2.0	2.0	.500
25 to 60	2.4	2.4	2.4	2.4	.417
30 to 40	1.33	1.33	1.33	1.33	.750
30 to 50	1.66	1.66	1.66	1.66	.600
30 to 60	2.0	2.0	2.0	2.0	.500
40 to 50	1.25	1.25	1.25	1.25	.800
40 to 60	1.5	1.5	1.5	1.5	.667
50 to 60	1.2	1.2	1.2	1.2	.833

Table III—Multipliers to Use When Lowering the Operating Frequency, the Horsepower Varying With the Speed.

Required Changes in Cycles	R.P.M.	Hp.	Line Voltage	Circ. Mils.	Turns
60 to 25	.417	.417	.417	.417	2.4
60 to 30	.500	.500	.500	.500	2.0
60 to 40	.667	.667	.667	.667	1.5
60 to 50	.833	.833	.833	.833	1.2
50 to 25	.500	.500	.500	.500	2.0
50 to 30	.600	.600	.600	.600	1.667
50 to 40	.800	.800	.800	.800	1.25
40 to 35	.625	.625	.625	.625	1.60
40 to 30	.750	.750	.750	.750	1.33
30 to 25	.833	.833	.833	.833	1.20

Change No. 2—With a change in cycles and poles the speed will be kept nearly constant, the voltage or turns changed to suit the new requirement and the hp. will depend on the speed.

Change No. 3—With a change in cycles and speed, the hp. is kept constant by varying either the line voltage or turns per coil or phase.

Change No. 4—With a change in cycles and poles, the speed is kept as nearly the same as possible, with a constant hp. by varying either line voltage or turns per coil or phase.

In what follows each case will be taken up in turn and a change worked out giving the reasons for each step. This will bring up all the details likely to be encountered in any type of cycle change.

Change No. 1—For the change in cycles only. Tables II and III can be used. In this case the number of poles in the winding will remain the same for both frequencies, but the speed, horsepower, etc., will vary with the cycles. When increasing the speed of a motor, do not run the rotor at a peripheral speed greater than 7,500 feet per minute (peripheral speed equals the diameter of a rotor in feet × 3.1416 × r.p.m.) at the new frequency.

Table II gives the multipliers to use when it is desired to raise the frequency. The first column gives the desired change; that is, 25 cycles to 30 cycles, 40 cycles to 60 cycles, etc. The other five columns indicate the effect of the change on the r.p.m., horsepower, line voltage, area in circ. mils or the cross section of copper per coil, and the turns per coil or phase.

For example, consider a 25-cycle, 10-hp., 4-pole, 220-volt, 3-phase, 750-r.p.m. motor which is to be changed to 60 cycles. On consulting Table II, and the 25- to 60-cycle line, we find that the r.p.m. will increase 2.4 times or 750 × 2.4 equals 1,800 r.p.m. The horsepower rating would then be 10 × 2.4 or 24, but to obtain this rating and to keep the torque and other electrical conditions in the motor the same, the line voltage will have to be increased to 2.4 × 220 or 528 volts. In most cases the line voltage must remain the same; then the turns per coil or phase must be changed as shown in the last column. In this case, the turns will have to be decreased. If the motor had ninety turns per phase on 25 cycles it should have 90 × .417 or 37½ turns on 60 cycles. The turns might be decreased by reconnecting in some cases, and the voltage brought to within 10 per cent of the required value, or the stator would have to be rewound. In case of either reconnection or rewinding, the cross section of copper must also be changed at the same time and by the amount indicated in the tables.

It will be noticed when studying the tables, that whenever the line voltage is raised, the table indicates that the same results can be obtained by decreasing the turns and that when the turns are decreased, the area of copper should be increased and *vice versa*. The following details refer to the table of possible changes at the top of this page.

Table III gives the values when the frequency is to be lowered. This table shows that the r. p. m. and horsepower will decrease, but in any case where the speed is reduced the maximum horsepower rating should be at least five per cent lower than the value given. This is due to the lessened ventilation at lower speeds.

The above is the simplest frequency change. A close study of Tables II and III will indicate what the effect on the performance of the

Table IV—Multipliers to Use When Changing the Cycles and Poles with Horsepower Also Changed

Change From	Poles	R.P.M.	Hp	Line Voltage	Circ. Mils.	Turns
2-Pole, 25-cycle to 60-cycle	4	1.2	1.2	1.2	1.2	0.833
	6	0.80	0.80	0.80	0.80	1.25
	8	0.60	0.60	0.60	0.60	1.667
	10	0.48	0.48	0.48	0.48	2.08
	12	0.40	0.40	0.40	0.40	2.50
4-Pole, 25-cycle to 60-cycle	2	4.80	4.80	4.80	4.80	0.208
	6	1.60	1.60	1.60	1.60	0.625
	8	1.20	1.20	1.20	1.20	0.833
	10	0.96	0.96	0.96	0.96	1.042
	12	0.80	0.80	0.80	0.80	1.25
6-Pole, 25-cycle to 60-cycle	2	7.20	7.20	7.20	7.20	0.139
	4	3.60	3.60	3.60	3.60	0.278
	8	1.80	1.80	1.80	1.80	0.556
	10	1.44	1.44	1.44	1.44	0.694
	12	1.20	1.20	1.20	1.20	0.833
8-Pole, 25-cycle to 60-cycle	2	9.60	9.60	9.60	9.60	0.103
	4	4.80	4.80	4.80	4.80	0.208
	6	3.20	3.20	3.20	3.20	0.3125
	10	1.92	1.92	1.92	1.92	0.52
	12	1.60	1.60	1.60	1.60	0.625
10-Pole, 25-cycle to 60-cycle	2	12.0	12.0	12.0	12.0	0.833
	4	6.0	6.0	6.0	6.0	0.167
	6	4.0	4.0	4.0	4.0	0.250
	8	3.0	3.0	3.0	3.0	0.333
	12	2.0	2.0	2.0	2.0	0.500
12-Pole, 25-cycle to 60-cycle	2	14.4	14.4	14.4	14.4	0.069
	4	7.2	7.2	7.2	7.2	0.139
	6	4.8	4.8	4.8	4.8	0.208
	8	3.6	3.6	3.6	3.6	0.278
	10	2.88	2.88	2.88	2.88	0.347

motor would be if it were connected to the new line frequency without any change in the winding or line voltage. Consider now a 50 cycle to 60 cycle change. The r.p.m. would be increased 1.2 times, likewise the horsepower, and the line voltage would have to be 1.2 times the 50-cycle voltage, which we will assume as 220. The new or 60-cycle voltage then equals 220 × 1.2 or 264. If the turns were not decreased and the motor put across a 220-volt, 60-cycle line, it would be operating on 83 per cent voltage or under voltage. This would reduce the maximum horsepower rating since the horsepower depends on the torque. Therefore, if the motor is operated on less than the required line voltage, it will develop less torque and consequently less horsepower. If the 50-cycle rating were 25 hp., its rating with correct line voltage on 60 cycles would be 1.2 × 25 equals 30 hp., but with 220 volts on 60 cycles the torque would be $(220 \div 264)^2$ or .69 which is 69 per cent of the 50-cycle torque. Then the 60-cycle rating at 220 volts would be (1.2 × .69 × 25) or 20.7 hp.

To determine what the horsepower rating will be at the new frequency when the turns or line voltage are not changed, the following formula can be used:

$$Hp. = R \times H \times T \times T.$$

In this, R equals the original horsepower rating before changing the cycles, H equals the figure under hp., in Tables II or III, and T the figure under turns in Tables II and III. In the 50 cycle to 60 cycle change cited above, the formula works out as follows: 25 × 1.2 × .833 × .833 equals 20.7 hp.

From the above it follows that when the frequency is raised and no change made in the turns or line voltage that the horsepower rating will be reduced below the low cycle rating regardless of the increased speed. On the other hand, when the frequency is lowered and no changes are made in the turns or line voltage, the horsepower rating will be increased, even when the figure under the horsepower column in Table III indicates that the horsepower should be lower. For example, consider a 20-hp., 60-cycle, 220-volt motor changed to 30 cycles. Table III shows that the line voltage should be reduced .50 or 50 per cent and that the horsepower will also be reduced, but if the line voltage is left at 220 the rating will be, according to the above formula, 20 × .5 × 2 × 2 equals 40 hp. In this case the heating would be 2.05 times as great as the area of copper is the same and the horsepower doubled and the speed reduced. The motor would then burn out if loaded up to 40 hp.

If it is desired to have the horsepower rating remain the same when changing the frequency, the voltage should be changed as the square

Tables V and VI—Multipliers to Use When Changing from 25 to 50 Cycles and from 25 to 40 Cycles with the Horsepower Also Changed

Change From	Poles	R.P.M. Line Volts Circ. Mils and Hp.	Turns	Change From	Poles	R.P.M. Line Volts Circ. Mils and Hp.	Turns
2-Pole, 25-cycle to 50-cycle	*4	1.0	1.0	2-Pole, 25-cycle to 40-cycle	4	0.800	1.25
	6	0.667	1.5		6	0.533	1.875
	8	0.50	2.0		8	0.400	2.50
	10	0.40	2.5		10	0.320	3.12
	12	0.33	3.0		12	0.267	3.75
4-Pole, 25-cycle to 50-cycle	2	4.0	0.25	4-Pole, 25-cycle to 40-cycle	2	3.20	0.313
	6	1.33	0.75		6	1.07	0.938
	*8	1.0	1.00		8	0.80	1.25
	10	0.80	1.25		10	0.64	1.56
	12	0.667	1.50		12	0.53	1.875
6-Pole, 25-cycle to 50-cycle	2	6.0	0.167	6-Pole, 25-cycle to 40-cycle	2	4.80	0.28
	4	3.0	0.333		4	2.40	0.416
	8	1.5	0.667		8	1.20	0.833
	10	1.2	0.833		10	0.96	1.04
	*12	1.0	1.00		12	0.80	1.25
8-Pole, 25-cycle to 50-cycle	2	8.0	0.125	8-Pole, 25-cycle to 40-cycle	2	6.40	0.156
	4	4.0	0.25		4	3.20	0.313
	6	2.667	0.375		6	2.12	0.47
	10	1.60	0.625		10	1.28	0.78
	12	1.30	0.75		12	1.13	0.937
10-Pole, 25-cycle to 50-cycle	2	10.00	0.10	10-Pole, 25-cycle to 40-cycle	2	8.00	0.125
	4	5.00	0.20		4	4.00	0.250
	6	3.33	0.30		6	2.67	0.375
	8	2.50	0.40		8	2.00	0.500
	12	1.667	0.60		12	1.33	0.75
12-Pole, 25-cycle to 50-cycle	2	12.00	0.083	12-Pole, 25-cycle to 40-cycle	2	9.60	0.104
	4	6.00	0.167		4	4.80	0.208
	6	4.00	0.25		6	3.20	0.313
	8	3.00	0.33		8	2.40	0.416
	10	2.40	0.417		10	1.92	0.520

Tables VII and VIII—Multipliers to Use When Changing from 25 to 30 Cycles and from 30 to 60 Cycles with the Horsepower Also Changed

Change From	Poles	R.P.M. Line Volts Circ. Mils. and Hp.	Turns	Change From	Poles	R.P.M. Line Volts Circ. Mils. and Hp.	Turns
2-Pole, 25-cycle to 30-cycle	4	0.60	1.67	2-Pole, 30-cycle to 60-cycle	*4	1.00	1.00
	6	0.40	2.50		6	0.667	1.50
	8	0.30	3.33		8	0.50	2.00
	10	0.24	4.16		10	0.40	2.50
	12	0.20	5.00		12	0.33	3.00
4-Pole, 25-cycle to 30-cycle	2	2.40	0.416	4-Pole, 30-cycle to 60-cycle	2	4.00	0.25
	6	0.80	1.25		6	1.33	0.75
	8	0.60	1.667		*8	1.00	1.00
	10	0.48	2.08		10	0.80	1.25
	12	0.40	2.50		12	0.667	1.50
6-Pole, 25-cycle to 30-cycle	2	3.60	0.278	6-Pole, 30-cycle to 60-cycle	2	6.00	0.167
	4	1.80	0.556		4	3.00	0.333
	8	0.90	1.111		8	1.50	0.667
	10	0.72	1.39		10	1.20	0.833
	12	0.60	1.667		*12	1.00	1.000
8-Pole, 25-cycle to 30-cycle	2	4.80	0.208	8-Pole, 30-cycle to 60-cycle	2	8.00	0.125
	4	2.40	0.416		4	4.00	0.25
	6	1.60	0.625		6	2.67	0.375
	10	0.96	1.04		10	1.60	0.625
	12	0.80	1.25		12	1.33	0.75
10-Pole, 25-cycle to 30-cycle	2	6.00	0.1667	10-Pole, 30-cycle to 60-cycle	2	10.00	0.10
	4	3.00	0.333		4	5.00	0.20
	6	2.00	0.500		6	3.33	0.30
	8	1.50	0.667		8	2.50	0.40
	*12	1.00	1.000		12	2.30	0.60
12-Pole, 25-cycle to 30-cycle	2	7.20	0.139	12-Pole, 30-cycle to 60-cycle	2	12.0	0.083
	4	3.60	0.278		4	6.0	0.167
	6	2.40	0.416		6	4.0	0.250
	8	1.80	0.556		8	3.0	0.333
	10	1.44	0.722		10	2.4	0.416

*Indicates that the winding can be reconnected and will operate at the same rating on the new frequency. Line voltage in all these tables means the original voltage before making the change in the motor.

root of the cycle change. Consider a change from 25 cycles to 40 cycles. If the voltage is 220 on 25 cycles, changing it to 220 × (40 ÷ 25) equals 220 × 1.264, or 278 volts on 40 cycles will keep the horsepower constant. Table XIV gives the multiple to use for each item when it is desired to make a change and have the horsepower remain constant.

It must be understood that when the *cycles* and speed are changed and the horsepower kept constant, a corresponding change in the cross section of copper must be made by reconnecting or rewinding the stator, as it is seldom possible to obtain such odd voltages as 278 as required in the above case. Then the only remedy is to vary the turns per coil or phase.

Change No. 2—The next change to consider is one where it is desired to change the cycles and keep the speed the same, allowing the horsepower to vary. Tables IV to XII are to be used for this type of change.

Consider a 40 cycle to 50 cycle change, the 40-cycle rating being 25 hp., 220 volts, three-phase, eight-pole, 600 r.p.m. On consulting Table I, 60-cycle column, we find that for 600 r.p.m. on 60 cycles a twelve-pole winding is required. From Table XII and the 40 cycle to 60 cycle change, we find in the 40-cycle, eight-pole section on the twelve-pole, 60-cycle horizontal line that the multiple for the hp., speed, line voltage, turns per phase or coil and circ. mils, is 1. This means that the 40-cycle winding, size of wire and turns is satisfactory for 60 cycles, at the same speed. The only other item requiring checking is the coil pitch. The 40-cycle winding is

Tables IX and X—Multipliers to Use When Changing from 30 to 50 Cycles and from 30 to 40 Cycles with the Horsepower Also Changed

Change From	Poles	R.P.M. Line Volts Circ. Mils. and Hp.	Turns	Change From	Poles	R.P.M. Line Volts Circ. Mils and Hp.	Turns
2 Pole,	4	0.833	1.20	2-Pole,	4	0.667	1.50
30-cycle	6	0.555	1.80	30-cycle	6	0.444	2.125
to	8	0.416	2.40	to	8	0.338	3.00
50-cycle	10	0.338	3.00	40-cycle	10	0.267	3.75
	12	0.278	3.60		12	0.222	4.50
4-Pole,	2	3.38	0.30	4-Pole,	2	2.67	0.375
30-cycle	6	1.10	0.90	30-cycle	6	0.89	1.125
to	8	0.833	1.20	to	8	0.667	1.50
50-cycle	10	0.667	1.50	40-cycle	10	0.533	1.875
	12	0.556	1.80		12	0.444	2.25
6-Pole,	2	5.00	0.20	6-Pole,	2	4.00	0.25
30-cycle	4	2.50	0.40	30-cycle	4	2.00	0.50
to	8	1.25	0.80	to	*8	1.00	1.00
50-cycle	*10	1.00	1.00	40-cycle	10	0.80	1.25
	12	0.833	1.20		12	0.667	1.50
8-Pole,	2	6.67	0.15	8-Pole,	2	5.33	0.1875
30-cycle	4	3.38	0.30	30-cycle	4	2.685	0.375
to	6	2.22	0.45	to	6	1.78	0.563
50-cycle	10	1.33	0.75	40-cycle	10	1.06	0.939
	12	1.11	0.90		12	0.89	1.125
10-Pole,	2	8.33	0.12	10-Pole,	2	6.67	0.15
30-cycle	4	4.16	0.24	30-cycle	4	3.38	0.30
to	6	2.78	0.36	to	6	2.22	0.45
50-cycle	8	2.08	0.48	40-cycle	8	1.667	0.60
	12	1.39	0.72		12	1.11	0.90
12-Pole,	2	10.0	0.10	12-Pole,	2	8.00	0.125
30-cycle	4	5.0	0.20	30-cycle	4	4.00	0.25
to	6	3.33	0.30	to	6	2.66	0.375
50-cycle	8	2.50	0.40	40-cycle	8	2.00	0.50
	10	2.00	0.50		10	1.60	0.625

Tables XI and XII—Multipliers to Use When Changing from 40 to 50 Cycles and from 40 to 60 Cycles with the Horsepower Also Changed

Change From	Poles	R.P.M. Line Volts Circ. Mills and Hp.	Turns	Change From	Poles	R.P.M. Line Volts Circ. Mils and Hp.	Turns
2-Pole,	4	0.625	1.60	2-Pole,	4	0.750	1.33
40-cycle	6	0.416	2.40	40-cycle	6	0.500	2.00
to	8	0.313	3.20	to	8	0.375	2.67
50-cycle	10	0.250	4.00	60-cycle	10	0.300	3.33
	12	0.208	4.80		12	0.250	4.00
4-Pole,	2	2.50	0.40	4-Pole,	2	3.000	0.333
40-cycle	6	0.833	1.20	40-cycle	*6	1.000	1.000
to	8	0.625	1.60	to	8	0.750	1.33
50-cycle	10	0.500	2.00	60-cycle	10	0.600	1.667
	12	0.416	2.40		12	0.500	2.000
6-Pole,	2	3.75	0.267	6-Pole,	2	4.50	0.222
40-cycle	4	1.875	0.533	40-cycle	4	2.25	0.444
to	8	0.938	1.07	to	8	1.125	0.89
50-cycle	10	0.750	1.33	60-cycle	10	0.900	1.11
	12	0.625	1.60		12	0.750	1.33
8-Pole,	2	5.000	0.200	8-Pole,	2	6.000	0.167
40-cycle	4	2.50	0.400	40-cycle	4	3.000	0.334
to	6	1.667	0.600	to	6	2.000	0.500
50-cycle	*10	1.000	1.000	60-cycle	10	1.200	0.833
	12	0.833	1.200		*12	1.000	1.000
10-Pole,	2	6.25	0.160	10-Pole,	2	7.500	0.133
40-cycle	4	3.125	0.320	40-cycle	4	3.750	0.266
to	6	2.08	0.480	to	6	2.500	0.400
50-cycle	8	1.56	0.640	60-cycle	8	1.875	0.533
	12	1.04	0.960		12	1.250	0.800
12-Pole,	2	7.50	0.133	12-Pole,	2	9.000	0.111
40-cycle	4	3.75	0.266	40-cycle	4	4.500	0.222
to	6	2.50	0.400	to	6	3.000	0.333
50-cycle	8	1.875	0.533	60-cycle	8	2.250	0.444
	10	1.500	0.667		10	1.800	0.555

*Indicates that the winding can be reconnected and will operate at the same rating on the new frequency.

Table XIII—Multipliers to Use When Changing from 50 to 60 Cycles With the Horsepower Also Changed

Change From	Poles	R. P. M. Line Volts Circ. Mils and Hp.	Turns
2-Pole,	4	0.600	1.667
50-cycle	6	0.400	2.500
to	8	0.300	3.330
60-cycle	10	0.240	4.166
	12	0.200	5.000
4-Pole,	2	2.40	0.416
50-cycle	6	0.80	1.250
to	8	0.60	1.667
60-cycle	10	0.48	2.08
	12	0.40	2.50
6-Pole,	2	3.60	0.278
50-cycle	4	1.80	0.556
to	8	0.90	1.111
60-cycle	10	0.72	1.380
	12	0.60	1.667
8-Pole,	2	4.80	0.208
50-cycle	4	2.40	0.416
to	6	1.60	0.625
60-cycle	10	0.96	1.04
	12	0.80	1.25
10-Pole,	2	6.00	0.1667
50-cycle	4	3.00	0.3334
to	6	2.00	0.5000
60-cycle	8	1.50	0.6667
	*12	1.00	1.0000
12-Pole,	2	7.20	0.138
50-cycle	4	3.60	0.278
to	6	2.40	0.416
60-cycle	8	1.80	0.556
	10	1.44	0.694

*Indicates that the winding can be reconnected and will operate at the same rating on new frequency.

8-pole; there are seventy-two coils and slots, pitch 1-and-8, or two slots under full pitch. The 60-cycle winding requires twelve poles. Pitch for twelve poles should be 72 ÷ 12 equals 6 or 1-and-7 for full pitch. Then as the present coil is 1-and-8, it would be one slot over pitch for the twelve-pole winding, but as over pitch has the same effect as under pitch, the 40-cycle winding can be used without any change being made in the motor. The effect of one slot difference will not affect the performance to any extent.

This change brings up another point that must be considered; that is, the coil pitch, when making a change in the number of poles. The pitch must never be less than 50 per cent of full pitch, and in some cases it might be possible to change the consequent poles by reconnecting 4 to 8, 6 to 12 poles, etc. But when the low pole winding is full pitch, it is impossible to double the poles by reconnecting for consequent poles, as the two halves of the coils in each slot will neutralize each other. For the best results the low pole coil pitch should be 70 to 50 per cent of full pitch as 50 per cent pitch would be 100 per cent or full pitch for twice the number of poles. Therefore, with this type of change it may be necessary to spring the coils back or rewind with new coils to get the proper pitch. When rewinding for a larger or smaller number of poles be sure to use the same percentage of coil pitch in the new winding as was used in the old one.

Tables IV to XII are worth studying as they show a number of possible changes. For instance, Table XII, 40 to 60 cycles, in the 40-cycle, four-pole section we find that at 60 cycles and six poles the hp. etc., is the same. The only item to check is the coil pitch. With the two-pole winding, the hp., etc., will be three times the 40-cycle rating, as it is possible to increase or decrease the rating by the right number of poles on the new frequency.

Consider another speed and cycle change. Take a 30 cycle to 40 cycle change, the 30-cycle rating being 10 hp., 110 volts, two-phase, four-pole, 900 r.p.m. The nearest 40-cycle speed is 800 r.p.m. On the six-pole, 40-cycle line (Table X), we find that the hp. will be 10 × .89 or 8.9 hp. and that the stator will have to be rewound with 1.125 times the 30-cycle turns and .89 times the 30-cycle circ. mils, or if desired, the horsepower could be kept constant as will be explained later.

Change No. 3—Tables IV to XII and XVI to XXV are arranged for

Table XIV—Multipliers to Use When Raising Cycles and Speed with the Horsepower Remaining the Same

Required Change in Cycles	R.P.M.	Hp.	Line Volts	Circ. Mils.	Turns
25 to 30	1.2	1.0	1.099	1.099	.916
25 to 40	1.6	1.0	1.261	1.26	.790
25 to 50	2.0	1.0	1.414	1.414	.707
25 to 60	2.4	1.0	1.55	1.55	.646
30 to 40	1.33	1.0	1.15	1.15	.864
30 to 50	1.66	1.0	1.28	1.28	.771
30 to 60	2.00	1.0	1.414	1.414	.707
40 to 50	1.25	1.0	1.12	1.12	.896
40 to 60	1.50	1.0	1.22	1.22	.813
50 to 60	1.20	1.0	1.099	1.099	.916

Table XV—Multipliers to Use When Lowering Cycles and Speed with the Horsepower Remaining the Same

Required Change in Cycles	R.P.M.	Hp.	Line Volts	Circ. Mils.	Turns
60 to 25	.417	1.0	0.6458	0.6458	1.549
60 to 30	.500	1.0	0.7070	0.7070	1.414
60 to 40	.667	1.0	0.8167	0.8167	1.225
60 to 50	.833	1.0	0.9127	0.9127	1.095
50 to 25	.500	1.0	0.7070	0.7070	1.414
50 to 30	.600	1.0	0.7746	0.7746	1.291
50 to 40	.800	1.0	0.8944	0.8944	1.114
40 to 25	.625	1.0	0.7900	0.7900	1.265
40 to 30	.750	1.0	0.8660	0.8660	1.153
30 to 25	.833	1.0	0.9127	0.9127	1.095

Table XVI—Multipliers to Use When Changing from 25 to 60 Cycles with the Horsepower Remaining the Same

Change From	Poles	R.P.M.	Hp.	Line Volts	Circ. Mils.	Turns
2-Pole, 25-cycle to 60-cycle	4	1.2	1.0	1.099	1.099	0.916
	6	0.80	1.0	0.894	0.894	1.115
	8	0.68	1.0	0.825	0.825	1.213
	10	0.48	1.0	0.693	0.693	1.443
	12	0.40	1.0	0.632	0.632	1.580
4-Pole, 25-cycle to 60-cycle	2	4.80	1.0	2.186	2.186	0.457
	6	1.60	1.0	1.260	1.260	0.790
	8	1.20	1.0	1.099	1.099	0.916
	10	0.96	1.0	0.980	0.980	1.020
	12	0.80	1.0	0.894	0.894	1.118
6-Pole, 25-cycle to 60-cycle	2	7.20	1.0	2.682	2.682	0.373
	4	3.60	1.0	1.898	1.898	0.526
	8	1.80	1.0	1.342	1.342	0.746
	10	1.44	1.0	1.200	1.200	0.833
	12	1.20	1.0	1.099	1.099	0.916
8-Pole, 25-cycle to 60-cycle	2	9.60	1.0	3.100	3.100	0.322
	4	4.80	1.0	2.186	2.186	0.457
	6	3.20	1.0	1.789	1.789	0.558
	10	1.92	1.0	1.386	1.386	0.722
	12	1.60	1.0	1.260	1.260	0.790
10-Pole, 25-cycle to 60-cycle	2	12.00	1.0	3.46	3.46	0.288
	4	6.00	1.0	2.45	2.45	0.408
	6	4.00	1.0	2.00	2.00	0.500
	8	3.00	1.0	1.73	1.73	0.576
	12	2.00	1.0	1.414	1.414	0.707
12-Pole, 25-cycle to 60-cycle	2	14.40	1.0	3.789	3.789	0.263
	4	7.20	1.0	2.682	2.682	0.373
	6	4.80	1.0	2.186	2.186	0.457
	8	3.60	1.0	1.898	1.898	0.526
	10	2.88	1.0	1.698	1.698	0.587

Table XVII—Multipliers to Use When Changing from 25 to 50 Cycles with the Horsepower Remaining the Same

Change From	Poles	R. P M.	Hp.	Line Volts	Circ. Mils.	Turns
2-Pole 25-cycle to 50-cycle	4	1.0	1.0	1.0	1.0	1.0
	6	0.667	1.0	0.817	0.817	1.225
	8	0.500	1.0	0.707	0.707	1.414
	10	0.400	1.0	0.632	0.632	1.58
	12	0.33	1.0	0.574	0.574	1.74
4-Pole, 25-cycle to 50-cycle	2	0.40	1.0	0.632	0.632	1.58
	6	1.33	1.0	1.153	1.153	0.868
	8	1.00	1.0	1.0	1.0	1.0
	10	0.80	1.0	0.894	0.894	1.115
	12	0.667	1.0	0.817	0.817	1.125
6-Pole, 25-cycle to 50-cycle	2	6.0	1.0	2.45	2.45	0.408
	4	3.0	1.0	1.73	1.73	0.576
	8	1.5	1.0	1.225	1.225	0.816
	10	1.2	1.0	1.099	1.099	0.916
	12	1.0	1.0	1.0	1.0	1.0
8-Pole, 25-cycle to 50-cycle	2	8.0	1.0	2.828	2.828	0.354
	4	4.0	1.0	2.000	2.000	0.500
	6	2.667	1.0	1.634	1.634	0.613
	10	1.60	1.0	1.260	1.260	0.790
	12	1.30	1.0	1.140	1.140	0.877
10-Pole, 25-cycle to 50-cycle	2	10.00	1.0	3.162	3.162	0.316
	4	5.00	1.0	2.236	2.236	0.446
	6	3.33	1.0	1.825	1.825	0.548
	8	2.50	1.0	1.581	1.581	0.633
	12	1.667	1.0	1.292	1.292	0.776
12-Pole, 25-cycle to 50-cycle	2	12.00	1.0	3.460	3.460	0.288
	4	6.00	1.0	2.450	2.450	0.408
	6	4.00	1.0	2.000	2.000	0.500
	8	3.00	1.0	1.732	1.732	0.576
	10	2.40	1.0	1.549	1.549	0.645

use in making a combined cycle and speed change. The first column gives the original cycles, poles two to twelve, and each pole section is divided into five horizontal sections. Each line represents a new pole grouping at the required frequency. It will be noticed that the number of poles used in the first column is not repeated in the second column of the same section. The remaining columns give a multiple to get the required results. In Tables IV to XIII the number in the third column indicates what the speed and horsepower would be at the new cycles and poles, also what the line voltage should be. If the line voltage can not be varied then the turns in the old winding must be varied, according to the fourth column. The circ. mils also change as shown in the proper column. The above also applies to Tables XVI to XXV.

Now consider this third type of change; that is, changing cycles and speed, but the horsepower remaining constant. In order to accomplish this the torque must be increased when the speed is decreased or *vice versa.* This is done by changing the voltage or turns in the correct amount. Tables XIV and XV

Table XVIII—Multipliers to Use When Changing from 25 to 40 Cycles with the Horsepower Remaining the Same

Change From	Poles	R.P.M.	Hp.	Line Volts	Circ. Mils.	Turns
2-Pole,	4	0.800	1.0	0.894	0.894	1.115
25-cycle	6	0.533	1.0	0.730	0.730	1.369
to	8	0.400	1.0	0.632	0.632	1.580
40-cycle	10	0.320	1.0	0.566	0.566	1.765
	12	0.267	1.0	0.517	0.517	1.936
4-Pole,	2	3.200	1.0	1.789	1.789	0.558
25-cycle	6	1.070	1.0	1.034	1.034	0.967
to	8	0.800	1.0	0.894	0.894	1.115
40-cycle	10	0.640	1.0	0.800	0.800	1.250
	12	0.530	1.0	0.728	0.728	1.372
6-Pole,	2	4.800	1.0	2.186	2.186	0.457
25-cycle	4	2.400	1.0	1.549	1.549	0.645
to	8	1.200	1.0	1.099	1.099	0.916
40-cycle	10	0.960	1.0	0.980	0.980	1.020
	12	0.800	1.0	0.894	0.894	1.115
8-Pole,	2	6.400	1.0	2.529	2.529	0.398
25-cycle	4	3.200	1.0	1.789	1.789	0.558
to	6	2.120	1.0	1.456	1.456	0.686
40-cycle	10	1.280	1.0	1.131	1.131	0.884
	12	1.130	1.0	1.063	1.063	0.942
10-Pole,	2	8.000	1.0	2.828	2.828	0.354
25-cycle	4	4.000	1.0	2.000	2.000	0.500
to	6	2.670	1.0	1.634	1.634	0.613
40-cycle	8	2.000	1.0	1.414	1.414	0.707
	12	1.330	1.0	1.153	1.153	0.868
12-Pole,	2	9.600	1.0	3.100	3.100	0.322
25-cycle	4	4.800	1.0	2.186	2.186	0.457
to	6	3.200	1.0	1.789	1.789	0.558
40-cycle	8	2.400	1.0	1.549	1.549	0.645
	10	1.920	1.0	1.386	1.386	0.722

Table XIX—Multipliers to Use When Changing from 25 to 30 Cycles with the Horsepower Remaining the Same

Change From	Poles	R.P.M.	Hp.	Line Volts	Circ. Mils.	Turns
2-Pole,	4	0.60	1.0	0.775	0.775	1.291
25-cycle	6	0.40	1.0	0.632	0.632	1.580
to	8	0.30	1.0	0.547	0.547	1.832
30-cycle	10	0.24	1.0	0.490	0.490	2.041
	12	0.20	1.0	0.447	0.447	2.235
4-Pole,	2	2.40	1.0	1.549	1.549	0.645
25-cycle	6	0.80	1.0	0.894	0.894	1.115
to	8	0.60	1.0	0.775	0.775	1.291
30-cycle	10	0.48	1.0	0.693	0.693	1.443
	12	0.40	1.0	0.632	0.632	1.580
6-Pole,	2	3.60	1.0	1.898	1.898	0.526
25-cycle	4	1.80	1.0	1.342	1.342	0.746
to	8	0.90	1.0	0.948	0.948	1.053
30-cycle	10	0.72	1.0	0.848	0.848	1.178
	12	0.60	1.0	0.775	0.775	1.291
8-Pole,	2	4.80	1.0	2.186	2.186	0.457
25-cycle	4	2.40	1.0	1.549	1.549	0.645
to	6	1.60	1.0	1.260	1.260	0.790
30-cycle	10	0.96	1.0	0.980	0.980	1.020
	12	0.80	1.0	0.894	0.894	1.115
10-Pole,	2	6.00	1.0	2.450	2.450	0.408
25-cycle	4	3.00	1.0	1.732	1.732	0.576
to	6	2.00	1.0	1.414	1.414	0.707
30-cycle	8	1.50	1.0	1.220	1.220	0.813
	12	1.00	1.0	1.000	1.000	1.000
12-Pole,	2	7.20	1.0	2.682	2.682	0.373
25-cycle	4	3.60	1.0	1.898	1.898	0.526
to	6	2.40	1.0	1.549	1.549	0.645
30-cycle	8	1.80	1.0	1.342	1.342	0.746
	10	1.44	1.0	1.200	1.200	0.833

Table XX—Multipliers to Use When Changing from 30 to 60 Cycles with the Horsepower Remaining the Same

Change From	Poles	R.P.M.	Hp.	Line Volts	Circ. Mils.	Turns
2-Pole,	4	1.000	1.0	1.000	1.000	1.000
30-cycle	6	0.667	1.0	0.817	0.817	1.225
to	8	0.500	1.0	0.707	0.707	1.414
60-cycle	10	0.400	1.0	0.632	0.632	1.580
	12	0.330	1.0	0.574	0.574	1.740
4-Pole,	2	4.00	1.0	2.000	2.000	0.500
30-cycle	6	1.33	1.0	1.150	1.150	0.861
to	8	1.00	1.0	1.000	1.000	1.000
60-cycle	10	0.80	1.0	0.894	0.894	1.115
	12	0.67	1.0	0.818	0.818	1.220
6-Pole,	2	6.00	1.0	2.450	2.450	0.408
30-cycle	4	3.00	1.0	1.732	1.732	0.576
to	8	1.50	1.0	1.220	1.220	0.813
60-cycle	10	1.20	1.0	1.099	1.099	0.916
	12	1.00	1.0	1.000	1.000	1.000
8-Pole,	2	8.00	1.0	2.828	2.828	0.354
30-cycle	4	4.00	1.0	2.000	2.000	0.500
to	6	2.67	1.0	1.634	1.634	0.613
60-cycle	10	1.60	1.0	1.260	1.260	0.790
	12	1.30	1.0	1.140	1.140	0.877
10-Pole,	2	10.00	1.0	3.162	3.162	0.316
30-cycle	4	5.00	1.0	2.236	2.236	0.446
to	6	3.33	1.0	1.825	1.825	0.548
60-cycle	8	2.50	1.0	1.581	1.581	0.633
	12	2.30	1.0	1.516	1.516	0.659
12-Pole,	2	12.00	1.0	3.460	3.460	0.288
30-cycle	4	6.00	1.0	2.450	2.450	0.408
to	6	4.00	1.0	2.000	2.000	0.500
60-cycle	8	3.00	1.0	1.732	1.732	0.576
	10	2.40	1.0	1.549	1.549	0.645

Table XXI—Multipliers to Use When Changing from 30 to 50 Cycles with the Horsepower Remaining the Same

Change From	Poles	R.P.M.	Hp.	Line Volts	Circ. Mils.	Turns
2-Pole,	4	0.833	1.0	0.912	0.912	1.094
30-cycle	6	0.555	1.0	0.744	0.744	1.340
to	8	0.416	1.0	0.645	0.645	1.550
50-cycle	10	0.338	1.0	0.581	0.581	1.718
	12	0.278	1.0	0.527	0.527	1.890
4-Pole,	2	3.380	1.0	1.838	1.838	0.544
30-cycle	6	1.100	1.9	1.048	1.048	0.952
to	8	0.833	1.0	0.912	0,912	1.094
50-cycle	10	0.667	1.0	0.817	0.817	1.225
	12	0.555	1.0	0.744	0.744	1.340
6-Pole,	2	5.000	1.0	2.236	2.236	0.446
30-cycle	4	2.500	1.0	1.581	1.581	0.633
to	8	1.250	1.0	1.120	1.120	0.896
50-cycle	10	1.000	1.0	1.000	1.000	1.000
	12	0.833	1.0	0.912	0.912	1.094
8-Pole,	2	6.67	1.0	2.582	2.582	0.387
30-cycle	4	3.38	1.0	1.838	1.838	0.543
to	6	2.22	1.0	1.489	1.489	0.670
50-cycle	10	1.33	1.0	1.150	1.150	0.864
	12	1.11	1.0	1.054	1.054	0.949
10-Pole,	2	8.33	1.0	2.707	2.707	0.325
30-cycle	4	4.16	1.0	2.039	2.039	0.490
to	6	2.78	1.0	1.667	1.667	0.600
50-cycle	8	2.08	1.0	1.442	1.442	0.693
	12	1.39	1.0	1.179	1.179	0.848
12-Pole,	2	10.00	1.0	3.162	3.162	0.316
30-cycle	4	5.00	1.0	2.236	2.236	0.446
to	6	3.33	1.0	1.825	1.825	0.548
50-cycle	8	2.50	1.0	1.581	1.581	0.633
	10	2.00	1.0	1.414	1.414	0.707

give the multiple for each factor. Table XIV on the 30- to 60-cycle line, indicates that a 30-cycle motor to operate on 60 cycles will have the speed increased 100 per cent and to keep the horsepower the same the 60-cycle line voltage must be 1.414 times the 30-cycle voltage. If the voltage can not be varied then the turns will have to be .707 times the 30-cycle turns and the copper cross section 1.414 times the 30-cycle cross section of copper. Table XV can be used in the same way.

Change No. 4—The next type of change requires that the horsepower be kept constant and that the speed be kept as near as possible to the same value. Tables XVI to XXV give values for this type of change. Consider a 15-hp., 220-volt, three-phase, 25-cycle, 750-r.p.m. motor which it is desired to use on a 60-cycle, 220-volt line, and on an application that only requires 15 hp. On consulting Table XVI in the four-pole, 25-cycle section, we find an eight- or ten-pole winding can be used on 60 cycles. The eight-pole, 60-cycle winding r.p.m. will be 750×1.2 or 900 and the ten-pole will be $.96 \times 750$ or 720 r.p.m. With a ten-pole, (*Continued on page 211*)

Table XXII—Multipliers to Use When Changing from 30 to 40 Cycles with the Horsepower Remaining the Same

Change From	Poles	R.P.M.	Hp.	Line Volts	Circ. Mils.	Turns
2-Pole, 30-cycle to 40-cycle	4	0.667	1.0	0.817	0.817	1.225
	6	0.444	1.0	0.666	0.666	1.500
	8	0.338	1.0	0.581	0.581	1.718
	10	0.267	1.0	0.517	0.517	1.936
	12	0.222	1.0	0.471	0.471	2.121
4-Pole, 30-cycle to 40-cycle	2	2.67	1.0	1.634	1.634	0.613
	6	0.89	1.0	0.943	0.943	1.059
	8	0.667	1.0	0.817	0.817	1.225
	10	0.533	1.0	0.730	0.730	1.369
	12	0.444	1.0	0.666	0.666	1.500
6-Pole, 30-cycle to 40-cycle	2	4.000	1.0	2.000	2.000	0.500
	4	2.000	1.0	1.414	1.414	0.707
	8	1.000	1.0	1.000	1.000	1.000
	10	0.800	1.0	0.894	0.894	1.115
	12	0.667	1.0	0.817	0.817	1.225
8-Pole, 30-cycle to 40-cycle	2	5.33	1.0	2.308	2.308	0.433
	4	2.685	1.0	1.637	1.637	0.609
	6	1.78	1.0	1.334	1.334	0.749
	10	1.06	1.0	1.029	1.029	0.970
	12	0.89	1.0	0.943	0.943	1.059
10-Pole, 30-cycle to 40-cycle	2	6.67	1.0	2.582	2.582	0.387
	4	3.38	1.0	1.838	1.838	0.543
	6	2.22	1.0	1.489	1.489	0.670
	8	1.667	1.0	1.292	1.292	0.776
	12	1.11	1.0	1.054	1.054	0.949
12-Pole, 30-cycle to 40-cycle	2	8.0	1.0	2.282	2.282	0.354
	4	4.00	1.0	2.000	2.000	0.500
	6	2.67	1.0	1.634	1.634	0.613
	8	2.00	1.0	1.414	1.414	0.707
	10	1.60	1.0	1.260	1.260	0.790

Table XXIII — Multipliers to Use When Changing from 40 to 50 Cycles with the Horsepower Remaining the Same

Change From	Poles	R.P.M.	Hp.	Line Volts	Circ. Mils.	Turns
2-Pole, 40-cycle to 50-cycle	4	0.625	1.0	0.789	0.789	1.262
	6	0.416	1.0	0.645	0.645	1.550
	8	0.313	1.0	0.559	0.559	1.786
	10	0.250	1.0	0.500	0.500	2.000
	12	0.208	1.0	0.456	0.456	2.192
4-Pole, 40-cycle to 50-cycle	2	2.500	1.0	1.581	1.581	0.633
	6	0.833	1.0	0.912	0.912	1.094
	8	0.625	1.0	0.789	0.789	1.262
	10	0.500	1.0	0.707	0.707	1.414
	12	0.416	1.0	0.645	0.645	1.550
6-Pole, 40-cycle to 50-cycle	2	3.750	1.0	1.936	1.936	0.516
	4	1.875	1.0	1.369	1.369	0.730
	8	0.938	1.0	0.968	0.968	1.032
	10	0.750	1.0	0.866	0.866	1.115
	12	0.625	1.0	0.789	0.789	1.262
8-Pole, 40-cycle to 50-cycle	2	5.000	1.0	2.236	2.236	0.446
	4	2.500	1.0	1.581	1.581	0.633
	6	1.667	1.0	1.292	1.292	0.776
	10	1.000	1.0	1.000	1.000	1.000
	12	0.833	1.0	0.912	0.912	1.094
10-Pole, 40-cycle to 50-cycle	2	6.250	1.0	2.500	2.500	0.400
	4	3.125	1.0	1.767	1.767	0.568
	6	2.080	1.0	1.442	1.442	0.693
	8	1.560	1.0	1.249	1.249	0.800
	12	1.040	1.0	1.019	1.019	0.979
12-Pole, 40-cycle to 50-cycle	2	7.500	1.0	2.738	2.738	0.365
	4	3.750	1.0	1.936	1.936	0.516
	6	2.500	1.0	1.581	1.581	0.633
	8	1.875	1.0	1.368	1.368	0.729
	10	1.500	1.0	1.220	1.220	0.813

Table XXIV—Multipliers to Use When Changing from 40 to 60 Cycles with the Horsepower Remaining the Same

Change From	Poles	R.P.M.	Hp.	Line Volts	Circ. Mils.	Turns
2-Pole, 40-cycle to 60-cycle	4	0.750	1.0	0.866	0.866	1.115
	6	0.500	1.0	0.707	0.707	1.414
	8	0.375	1.0	0.612	0.612	1.632
	10	0.300	1.0	0.547	0.547	1.832
	12	0.250	1.0	0.500	0.500	2.000
4-Pole, 40-cycle to 60-cycle	2	3.000	1.0	1.732	1.732	0.576
	6	1.000	1.0	1.000	1.000	1.000
	8	0.750	1.0	0.866	0.866	1.115
	10	0.600	1.0	0.775	0.775	1.291
	12	0.500	1.0	0.707	0.707	1.414
6-Pole, 40-cycle to 60-cycle	2	4.500	1.0	2.121	2.121	0.471
	4	2.250	1.0	1.500	1.500	0.667
	8	1.125	1.0	1.060	1.060	0.942
	10	0.900	1.0	......	......	......
	12	0.750	1.0	0.866	0.866	1.115
8-Pole, 40-cycle to 60-cycle	2	6.000	1.0	2.450	2.450	0.408
	4	3.000	1.0	1.732	1.732	0.576
	6	2.000	1.0	1.414	1.414	0.707
	10	1.200	1.0	1.099	1.099	0.916
	12	1.000	1.0	1.000	1.000	1.000
10-Pole, 40-cycle to 60-cycle	2	7.500	1.0	2.738	2.738	0.365
	4	3.750	1.0	1.936	1.936	0.516
	6	2.500	1.0	1.581	1.581	0.633
	8	1.875	1.0	1.369	1.369	0.730
	12	1.250	1.0	1.120	1.120	0.896
12-Pole, 40-cycle to 60-cycle	2	9.000	1.0	3.000	3.000	0.333
	4	4.500	1.0	2.121	2.121	0.471
	6	3.000	1.0	1.732	1.732	0.576
	8	2.250	1.0	1.500	1.500	0.667
	10	1.800	1.0	1.342	1.342	0.746

Table XXV—Multipliers to Use When Changing from 50 to 60 Cycles with the Horsepower Remaining the Same

Change From	Poles	R.P.M.	Hp.	Line Volts	Circ. Mils.	Turns
2-Pole, 50-cycle to 60-cycle	4	0.600	1.0	0.775	0.775	1.291
	6	0.400	1.0	0.632	0.632	1.580
	8	0.300	1.0	0.547	0.547	1.832
	10	0.240	1.0	0.490	0.490	2.041
	12	0.200	1.0	0.447	0.447	2.235
4-Pole, 50-cycle to 60-cycle	2	2.400	1.0	1.549	1.549	0.645
	6	0.800	1.0	0.894	0.894	1.115
	8	0.600	1.0	0.775	0.775	1.291
	10	0.480	1.0	0.693	0.693	1.443
	12	0.400	1.0	0.632	0.632	1.580
6-Pole, 50-cycle to 60-cycle	2	3.600	1.0	1.898	1.898	0.526
	4	1.800	1.0	1.342	1.342	0.746
	8	0.900	1.0	0.948	0.948	1.053
	10	0.720	1.0	0.848	0.848	1.178
	12	0.600	1.0	0.775	0.775	1.291
8-Pole, 50-cycle to 60-cycle	2	4.800	1.0	2.186	2.186	0.457
	4	2.400	1.0	1.549	1.549	0.645
	6	1.600	1.0	1.260	1.260	0.790
	10	0.960	1.0	0.980	0.980	1.020
	12	0.800	1.0	0.894	0.894	1.115
10-Pole, 50-cycle to 60-cycle	2	6.000	1.0	2.450	2.450	0.408
	4	3.000	1.0	1.732	1.732	0.576
	6	2.000	1.0	1.414	1.414	0.707
	8	1.500	1.0	1.220	1.220	0.813
	12	1.000	1.0	1.000	1.000	1.000
12-Pole, 50-cycle to 60-cycle	2	7.200	1.0	2.682	2.682	0.373
	4	3.600	1.0	1.898	1.898	0.526
	6	2.400	1.0	1.549	1.549	0.645
	8	1.800	1.0	1.342	1.342	0.746
	10	1.440	1.0	1.200	1.200	0.833

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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Chicago, April, 1924

What Do Increased Speeds Give Us?

SPEEDS, like styles, change periodically, sometimes for the better and sometimes for the worse. It seems that the popular trend is toward more rapidly-moving machinery. The advocates of higher speeds hold out the attractions of increased production and lower first cost. On the other hand, claims are made that the resulting lower maintenance and reduced production delays from the lower-speed machinery overbalance the advantages of increased speed.

In deciding whether increased speeds are justified in a particular application, it is well to balance the relative advantages as applied to the case in question. This brings to mind the case of a billet mill with very high roll-table speeds. The purpose of this was to obtain a very fast mill. After the mill had been put in operation it was found that the table speeds were so high that there was excessive slippage of the steel billets on the rolls. This meant that the steel did not travel as fast as was intended; in fact, when the roll speed was reduced, the billet speed was increased.

There is also recalled the case of a coal bridge with a 200-ft. span and a trolley speed of 500 ft. per min. This high trolley speed could never be utilized because the average travel of the trolley was approximately 100 ft. and the trolley did not have time to accelerate to this speed. Increasing the gear ratio between the motor and the track wheels brought about a lower running speed, but actually decreased the traveling time of the trolley and greatly increased the number of trips made during a given time. This was due to the faster acceleration obtained through increasing the gear ratio.

Still another case may be mentioned—that of a skull cracker crane with a runway length of 100 ft. and a bridge motion speed of 200 ft. per min. Most of the movements made by the crane averaged about 10 ft. of travel. Obviously the high bridge speed was of no value; in fact, the bridge runway was not long enough to get the bridge up to full speed without danger of not being able to stop quickly enough to avoid running into the bumper at the other end of the runway.

Such examples as these illustrate the necessity of a very careful analysis of each case in which higher speeds are being considered, so that a careful balance may be drawn between the factors of production, first cost, maintenance and production delays. In many cases increased speeds will actually show economies and increased earnings, but indiscriminate use of them, just as a great many people follow the styles in clothing and hair bobbing, are not likely to produce the records operating men like to talk about.

Everybody's Business Is Nobody's Business

SO COMPLEX and varied are the every-day jobs of industrial men, that some sort of organization for accident prevention is imperative. The very large plants with many departments spread over wide areas have met this issue by establishing safety engineering organizations. Other establishments are getting good results through special committees whose members supervise or conduct regular inspections and prepare reports of findings for discussion by themselves and their executives.

Now a movement is getting under way to turn the thinking of maintenance men into safety engineering channels. This idea is just as practical as it is brilliant. Such men have "the run of the plant," which removes their activities from the tender zones of interdepartmental authority. Since inspection forms such an important part of maintenance work in general, it would seem that the keen eyes and alert brains of the plant engineer's staff from the "big boss" down might well be more generally utilized in this very essential field of service. Of all this, more anon, but in the meantime let us be thinking about the fitness of maintenance personnel to undertake broader activities, co-operating with safety departments and committees where such are functioning, and pointing the way toward more thorough and systematic inspection in industrial plant operation as a whole.

Over-Motoring and Under-Motoring

SINCE manufacturers through the Electric Power Club standardized on one rating for general purpose motors, much of the confusion resulting from two standards of motor ratings has been eliminated and there should be no further cause for over-motoring or under-motoring. Over-motoring is poor practice from the industrial engineer's standpoint because it results in putting unnecessary expenditure in plant capitalization. Also, in the case of induction motors, it results in poor power factor requiring either a larger generating and distribution system or else power factor corrective apparatus, which necessitates a still larger increase in plant capitalization. Under-motoring is still worse because it runs up operating costs through increased maintenance and repairs and cuts down income through decreased production resulting from repairs and delays.

The factors governing motor applications and the traditions concerning what is required for a given installation have grown up around the 40-deg. motor. The industrial engineer in using any other rating governs himself to a large extent by his experience

with the 40-deg. motor and consequently many applications of 50-deg. motors have resulted in under-motoring an installation.

The adoption of the single standard of motor rating represents an economic saving not only to the manufacturers in standardization of designs and construction details, but also to the large number of motor users in the savings that will result from reduced plant investment and decreased maintenance due to correct motor applications.

How, Where and Why?

HERE'S a common-sense viewpoint that is worthy of some study. It is taken from the introduction of a sales bulletin, of an electrical instrument manufacturer, that says little about the instruments but much about the ways they can be used in industrial work to locate weak spots, to detect avoidable losses and to prevent troubles. Its obvious purpose is to sell instruments, but the way it goes about it reflects a knowledge of the operator's problems and carries the conviction that when the operator realizes what he can accomplish with them, his good judgment will either dictate the purchase or open negotiations leading thereto without a flowery dissertation on the excellence of design and the usual sales verbiage that carries little practical information but much display of expensive and complicated illustrations and general talk.

> As a nation we are reputed to be the keenest manufacturers on the globe and certain it is that when we buy raw materials or anything else entering into the cost of our products. we display unusual caution and intelligence. If this be so, why is it that the same degree of supervision as to cost and efficiency has not been generally applied to the purchase and use of electrical energy and electrical equipment?
>
> The only conceivable answer is that the opportunities for saving have not been understood or else the subject has not been carefully studied; for it is obvious that electrical power costs money to generate and distribute and that like any other commodity it is susceptible to waste if not properly utilized. Furthermore, our knowledge of factory equipment in general convinces us that mechanical or electrical equipment must be kept in the most ideal condition if we desire to prolong its life and make it do the maximum amount of useful work.
>
> The preceding remarks have a direct bearing upon the question of profits, for it is well known that there are two ways of increasing profits: one being to increase selling prices without additional manufacturing costs; the other, and more satisfactory method, being that of reducing manufacturing costs while maintaining usual selling prices, thus avoiding encouragement of competition. And it is with this latter method that the following pages deal.
>
> Lest you say to yourself that our remarks are merely a cloak to conceal the fact that we eventually hope to sell you some testing instruments, we at once proceed to remove any doubt on that score by acknowledging that our case is exactly like your own in that we are in business to sell the products which we manufacture. However, we wish to emphasize this significant fact: namely, that we do not want to sell without rendering service and for every sale we make of the apparatus referred to in this book, our profits shall be reasonable and made only once, whereas your profit derived through its use by saving energy and protecting your electrical equipment, should annually be more than tenfold ours and should continue indefinitely.

Most pieces of literature produced by a manufacturer dealing with the products he makes and sells are interesting reflections of the way readers do not use that literature. The general impression that the usual catalog gives is that the user and buyer of the apparatus needs an equipment dictionary which he can consult, with competitive sales information on how good the material or equipment is and information to prove that everybody is using it. *How, where* and *why* the product is used are points left to the imagination. And yet answers to questions on how, where and why are the points around which discussions revolve when talking with a prospective buyer on his home ground, where the practical problems of a job to be done that needs this or that piece of apparatus forces answers to these questions.

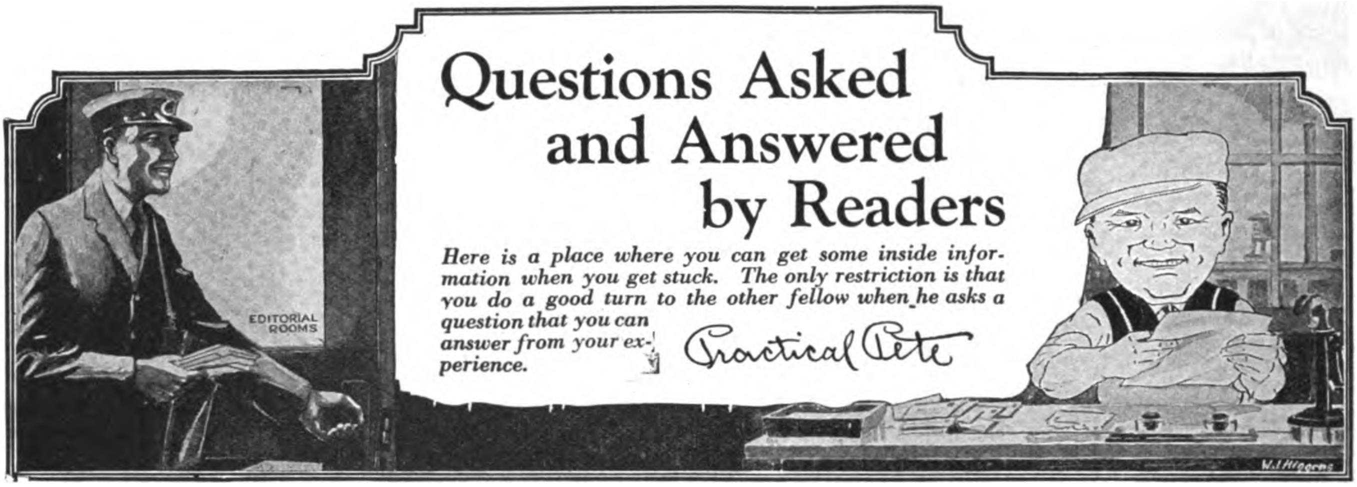
Moreover, a good answer to the *why* will often suggest an answer to the *how* and *where* in the mind of the user because he has the everyday problem of improving operations, installing new ones, avoiding troubles and reducing existing costs. He usually knows *where* to direct his attention but on *how* and *why* he should use something new or different, there is a wide opportunity for difference of opinion and a whole lot of conversation. Out of this the manufacturer wins or loses a customer. If he has a good argument on his side in answer to the *why* of the problem and it will save money or improve operation the chances for a sale are good. But when the silent salesman in the form of a bulletin says nothing or little about the *how, where* and *why,* it's just a piece of printed matter for which most of us have little more than a flying glance.

When Temporary Installations Become Permanent

ORDINARILY it is good policy to obey orders, or be able to show very good reasons for not doing so. However, when such orders conflict with the teachings of experience, the man to whom the instructions have been given is confronted with a situation which requires much tact and good judgment for its solution. The manner in which the foreman in charge of the installation and maintenance of lineshafts and other power service equipment handles such situations was recently told by the electrical engineer of a large works.

"Often during our rush season it is necessary to rearrange machines or put up new lineshafts and countershafts. Frequently these are intended to be only temporary installations and it is very important to get them into operation as soon as possible—for every hour may mean a heavy loss in production—but I can't get John to do anything except a first-class job. I have given him the strictest orders to hurry things through, and I have threatened him with all sorts of penalties, but it doesn't do any good. He doesn't argue about it, but I can't force him to turn over the job until everything is properly lined up and in good shape. For him, temporary installations simply do not exist—and he is absolutely right!"

So-called temporary installations have their place, of course, but unless they have been put in to meet an emergency and are removed or revamped after they have served that particular purpose they assume the status of permanent, poorly-aligned, power-wasting installations of lineshafts, chains, gears and all of the other elements of power drives. The few dollars that may be saved by doing a hurried, slipshod job of installation are soon wasted by the friction and other losses —and then these losses must be paid out of the profits of the business.



Who Can Answer These?

Removing Flange Couplings from Lineshafting—In the rearrangement of a group of machines, it was necessary to remove some solid pulleys from a lineshaft and replace them with others. This necessitated removing and replacing the flange couplings. We were not able to replace them so that they would run true and had to turn them down. I would like to know how other readers remove and replace flange couplings on lineshafts.
North Chicago, Ill. G. F. H.

* * * *

Meaning of Motor Nameplate Data—Can some reader tell me what "Open Hp. 10, Amps. 75,—Closed Hp. $5\frac{1}{2}$, Amps. 43," means in the case of a General Electric, d. c., compound-wound motor which has the following nameplate data: No. 95790, Form B, Speed 650, Volts 115, Open Hp. 10, Amps. 75—Closed Hp. $5\frac{1}{2}$, Amps. 43. Pat'd Feb. 14-88 up to Jan. 31-99.
Mazatlan, Sinaloa, Mex. J. C. L.

* * * *

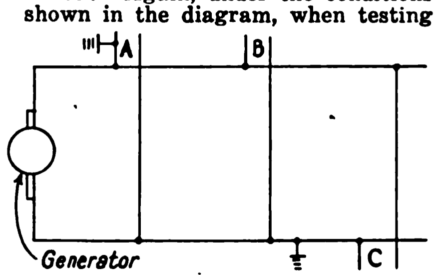
Supporting Load from Concrete Ceiling—In the rearrangement of the plant with which I am connected, we frequently find it necessary to suspend conveyors, motor platforms, countershafts, heavy radiators, and similar equipment from the ceiling of a reinforced concrete building. I am wondering if any of the readers of INDUSTRIAL ENGINEER have any information on how heavy a load can be supported from expanded bolts. I would also like to find out what other readers consider the best method of fastening equipment to the ceiling.
Chicago, Ill. E. D. F.

* * * *

Does Voltage Above Normal Affect Power Bill?—We buy power from a local power company at a line voltage of 13,000 volts. The voltage in the plant is supposed to be 550, but we have an average voltage of 640 to 700. Our motors are of the induction type, ranging from $\frac{1}{10}$ to 50 hp. Will there be any loss of power with the voltage higher than normal? If so, what will it amount to? When the voltage jumps from 620 to 700 our indicating wattmeter will rise around 200 watts. Will this increase the reading of our kw.-hr. meter in proportion, or what per cent will it be? I have been checking very closely the power consumed and find that when we have high voltage the power runs higher also. I shall be very grateful for any information you can give me.
Rock Hill, S. C. L. W. M.

* * * *

Why Do Grounds Not Blow Fuses in Power House?—It always takes two grounds of opposite polarity to make a short circuit. In cities or in large industrial plants where there is much conduit work, there must be grounds. If there is a ground on the negative side of one building and a ground on the positive side of another, why would these not blow the main fuse or open the breaker in the power house? Again, under the conditions shown in the diagram, when testing



out building *C*, would it not be possible to obtain results which would make one think that there is a ground somewhere in this building whereas it is located in building *A* or *B*?
Worcester, Mass. F. R. B.

* * * *

Trouble with Single-Phase Induction Motor—Can some of the readers of INDUSTRIAL ENGINEER tell me what is the matter with a small, single-phase induction motor which fails to start when the switch is closed? Both the main and starting windings and the centrifugal switch have been tested and seem to be all right. After closing the line switch and giving the rotor a quick start by means of a string, the rotor will sometimes quickly come to a stop, or apparently lock. Then, possibly the next time the switch is closed the motor will start from rest and run normally. This is a standard make of four-pole, 60-cycle, 110-volt motor. I shall certainly appreciate any suggestions you can give me as to what is the trouble and how it can be remedied.
Uhrichsville, Ohio. R. F. P.

Answers Received To Questions Asked

Portable Electric Grinder Lacks Power—I shall appreciate it if some of our readers will answer the following questions. I have a single-phase portable grinder which has two windings, starting and running, but the motor does not seem to have sufficient power when grinding. I should like to know if this motor could be re-connected for three-phase operation, eliminating the automatic cutout on the rotor. The motor has twenty-four slots $\frac{5}{8}$ in. deep and $\frac{5}{16}$ in. wide. The iron back of the slots is $\frac{3}{8}$ in. thick. Inside diameter of stator is $3\frac{1}{8}$ in., length of stator $2\frac{1}{2}$ in., diameter of rotor $3\frac{1}{16}$ in. If this change is possible, what size wire and how many turns should be used and what will the pitch be? I should like to have it operate at 3,600 r.p.m.

I have a small blower motor which operates at 220 volts direct current, and wish to change it to operate at 110 volts direct current. Will I have to reconnect the armature or should it be entirely rewound? The commutator has twenty-four bars and the armature has twelve slots.
Medina, Ohio. C. F. N.

Answering C. F. N.'s question in the February issue, a single-phase motor when rewound for three-phase operation at the same voltage, speed and frequency will develop about $1\frac{1}{2}$ times the original, single-phase hp. rating. Therefore, the motor in question would develop more torque and horsepower on three-phase. Another advantage of the three-phase over the single-phase motor is the elimination of the cutout switch in the starting circuit. Considerable trouble is experienced with these switches sticking and not opening the circuit; this burns out the starting winding and very often the running winding is also ruined. It is a well-known fact that a polyphase motor is more efficient and gives less trouble than a single-phase motor.

The motor in question will be good for $\frac{3}{4}$ hp. at 3,600 r.p.m. when

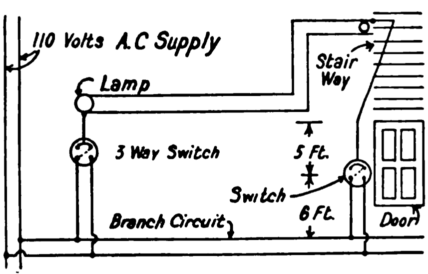
wound for two poles and operated on a three-phase, 60-cycle, 110-volt circuit. There will be twenty-four two-layer mush coils, each coil having sixteen turns of one No. 17 single-cotton and enamel-covered magnet wire, pitch 1 and 8, connected series-star, four coils per group with six groups. For 220 volts, use thirty-two turns of one No. 20 silk-covered and enameled wire, 1 and 8 pitch, with the coils connected series-star.

If possible to do so, I would use a No. 16 wire; this will increase the overload capacity. If high torque is required, use fourteen turns of No. 16 single-cotton and enameled wire with the coils connected series-star for 110 volts. The rotor is OK and will stand 3,600 r.p.m., but be sure that it is well balanced mechanically.

Detroit, Michigan. A. C. ROE.

* * * *

Protecting Wires from Mechanical Injury—How should the 5-ft. stretch of wire from floor to switch, shown in the accompanying diagram, be run for proper protection from mechanical injury? Knob and tube work is used throughout on this job, and the wire in question is to be installed in an unfinished stairway leading to a



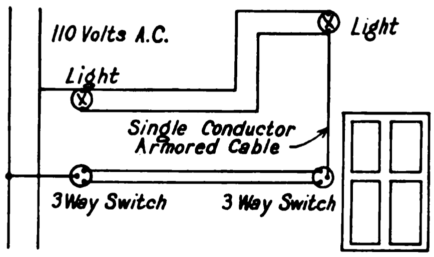
cellar. There is no partition through which to fish the wire. Further, when the wall of the stairway is finished it is to be back-plastered; so there will be no partition even then. I shall appreciate it if some reader can tell me the best way to meet the above conditions.

Concord, Mass. D. F.

In reply to D. F.'s inquiry in the February issue of INDUSTRIAL ENGINEER, the accompanying sketch shows a different method of wiring to accomplish the desired results.

In this arrangement only two soldered and taped joints are required to the feed lines, instead of four. Further, in case of an accidental short across the contacts of either three-way switch no fuse will blow or short circuit in the supply line.

The single wire connection from the three-way switch at the door to the light may be a No. 14 single-conductor, armored flexible cable, which is about 5/16-in. in diameter. If this is too large or for some other reason objectionable, a No. 14 rubber-covered wire may be pulled through a small, annealed copper or brass tube. If this is not feasible a single-conductor, braided copper insulated wire with flexible sheathing, as used in automobile wiring, can be used.



Use of single-conductor armored cable in place where wire is exposed to mechanical injury.

This is about 3/16-in. in diameter and is designed for carrying a low amperage current. E. H. LAABS.

Engineering Dept.,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

* * * *

Determining Charging Rate for Storage Battery—Can any of the readers of INDUSTRIAL ENGINEER tell me how to find out from a storage battery at what amperage it should be charged?
Temiskaming, Que., Can. J. H. F.

In answer to J. H. F.'s question in the December issue, the approximate charging rate of a storage battery may be determined by multiplying the square inch area of both sides of all the positive plates per cell by 0.04. For example, a power battery has seventeen plates per cell, each plate measuring 18 in. x 20 in. There will be eight positive plates: then $8 \times 2 \times 18 \times 20 \times 0.04 = 230.4$ or 230 amp. charging rate.

If the ampere-hour capacity of the battery is known, the rate may be determined by dividing this by 8. For example, with a battery rated at 1,000 amp.-hrs., $1{,}000 \div 8 = 125$ amp. charging rate.

General Electric Co., L. B. MORRILL.
Boston, Mass.

* * * *

J. H. F., whose question appeared in the December issue, should determine, first, whether the battery needs charging. This is done by placing a voltmeter across the terminals of one cell only. For a lead cell at full charge the voltmeter will read about 2.2 volts; an Edison cell at full charge will read about 1.5 volts. If the voltage of one lead cell reads about 1.8 volts it shows that a recharge is needed; a run-down Edison cell will read about 1.2 volts. In the case of the lead cells apply a direct current of a few amperes, say 8-15 amp. for a trial, to raise the reading of the voltmeter about one or two points. The high limit per cell must not exceed 2.6 volts and this limit should not be reached in a hurry. It should take 6-8 hr. if the battery is much run down. On the other hand, if the voltage does not rise noticeably after about 15 min. increase the charge in amperes, being careful not to heat the cells above 115 deg. F., and do not let the voltage per cell at any time get above 2.6 volts, which is the high limit while on charge.

With the Edison cells make the charge in amperes strong enough to raise the voltage of the meter slowly, taking 6-8 hr. for it to reach the upper limit of about 1.9 volts per cell, and not letting the temperature of the cells exceed 115 deg. F.

For an extended charge, more than 6-8 hr., with the solution temperature not above 115 deg. F., simply reduce the ampere charge enough to keep the voltmeter perhaps one point under the high limit and allow the latter to be reached very gradually. In short, do not exceed the temperature limit or the high voltage limit of any kind of a cell on charge, and the battery will not be injured, even if left on the line at a reduced charge for 12, 15, or 20 hr. H. S. RICH.

New Britain, Conn.

* * * *

The question by J. H. F. in the December issue could without doubt be answered best by the manufacturer from whom the battery was purchased. The charging rate depends upon the active battery surface in a cell and is likely to vary somewhat with different types.

In general for a lead-acid battery any charging rate is permissible that does not produce excessive gassing or a cell temperature greater than 110 deg. F. The value of the charging current at which gassing begins depends principally upon the state of charge of the battery. When a battery is fully discharged, a greater charging rate can be applied without causing gassing than if the battery is almost fully charged. For this reason the common practice is to start charging at a comparatively high rate at the beginning of charge, gradually reducing the rate as the charge progresses. By this method an average battery can be charged in about five hours.

By watching carefully the charging current, specific gravity, and temperature, a suitable charging rate can be determined, always bear-

ing in mind that it is necessary to keep temperature below 110 deg. F. and as soon as gassing is evident, to cut down on the charging rate.

Comerio Falls, FREDERICK KRUG.
Bayamon, Porto Rico.

* * * *

Answering the question by J.H.F. in the December issue, the charging rate of a storage battery may be calculated from the area of both sides of the positive plate, allowing 0.04 amp. per sq. in. That is, if the plate surface is 2,500 sq. in., then $0.04 \times 2,500 = 100$ amp., charging rate. JOHN H. GRIFFIN.
Cedar Rapids, Ia.

* * * *

Replying to J. H. F., whose question appeared in the December issue, when the charging rate of a storage battery is not given, and in the absence of instructions from the manufacturer of the battery, the charging rate may be determined approximately by calculation, taking .040 amp. per sq. in. of positive plate surface as normal. This may be verified after a few trials by noting the length of time elapsing from the beginning to the end of the charge, as evidenced by the voltage rising to 2.5 and vigorous gassing of the cell. The maximum charging rate is that at which the cell will absorb energy without heating more than 25 deg. F. above a reference temperature of 77 deg. F., or gassing excessively.

Denver, Colo. MARTIN G. LANE.

* * * *

Effect of Armature Coil with Reversed Polarity—Sometime ago this question was raised in our shop: Will a reversed polarity coil in an armature burn out while running, or what effect will it have on the armature?

I contend that in order to burn out a coil a heavy current must flow in that coil, which could only be caused by a short circuit. As all coils are connected in series, current of the same amount would flow in each; if one were reversed it would oppose the action of the others and having only the same amperage through it as the others it could only oppose with the strength of one coil, and would neutralize one armature coil.

I should like to hear from some of the readers of INDUSTRIAL ENGINEER on this question.

McKeesport, Pa. E. K.

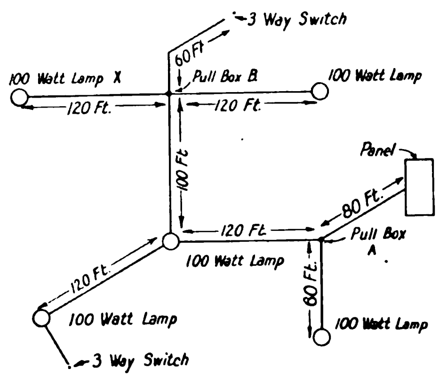
Replying to E. K.'s question in the February issue, I have never seen a reversed armature coil burn out. At the moment of commutation the coil will be under poles of the wrong polarity, causing a reverse emf. which opposes that of the other coils and causes excessive sparking at the brushes, and also lowers the efficiency of the machine.

The winding will heat up to some extent because the circuit containing the reversed coil will generate a lower voltage than the others, thereby causing a circulating current to flow through the winding.

Middleport, Ohio. ELZA HERRMANN.

* * * *

Why Do the Fuses on this Circuit Blow?—I recently wired a large concrete warehouse and should like to know why the 10-amp. fuses on the watchman's lighting circuit blow after the current has been on for a few hours. As shown in the diagram below, this circuit is controlled by two 3-way switches. No. 8 wire in 1-in. conduit is used throughout for this 110-volt a. c. circuit which con-



tains five 100-watt lamps. From the panel to the first pull box, *A*, a circuit of No. 12 wire runs in the same conduit, and from the pull box, *B*, through the light *X*, another circuit of No. 12 wire is pulled through the same conduit. A grounded neutral at the transformer secondary supplies this building. Can some reader help me out?

Los Angeles, Calif. A. W. W.

In answer to A. W. W.'s question in the January issue, I am of the opinion that he has a high-resistance ground on his circuit; perhaps this was caused by a small piece of insulation being nicked off a conductor at an outlet, while pulling in the wires. The length of time required for the fuses to reach their melting temperature may be due to the fact that only a small area of bare copper would be exposed, and that the enamel coating on the inside of the conduit has a high resistance. Again, the trouble may be caused by a pigtail splice, which is generally made at outlet boxes. A sliver of metal at the splice may have pierced the insulation and made contact with the box.

As the transformers are grounded at the secondary neutral I advise temporarily removing the ground wire from the conduit system. If the fuses fail to blow within a reasonable length of time it is evident that the circuit is grounded, even though the ground may be of high resistance. Then replace the ground wire and test for grounds in the usual way.

I hope the above information may assist A. W. W. in locating the trouble on his circuit.

New Orleans, La. OVIDE C. HARRIS.

* * * *

In reply to the question asked by A. W. W. in the January issue, I would suggest that he look for a loose connection close to the fuses, or a loose fuse receptacle or clips. I once had the same trouble on a house installation and after some time I found a loose plug receptacle.

Of course, a partial ground would also cause the fuses to blow; so I advise that he also test out the circuit for a slight ground.

I hope this information will be of some use to A. W. W.

Haledon, N. J. GEORGE ZEHNACKER.

* * * *

With reference to A. W. W.'s question in the January issue, from past experience I would say that he has one wire grounded in his condulet fittings at one or more places. Inasmuch as the conduit is grounded only through the concrete, which is of high resistance, the current flowing is not enough to blow the fuses immediately, but will allow them to heat slowly until they reach their melting point. Then they go out.

I would suggest that A. W. W. ground his conduit to a water pipe or other good ground and open the circuit at any convenient place. Be sure to keep the ends of the wires from touching anything. Then throw in the switch at the panel and if the fuses blow immediately it shows that the trouble lies between the place opened and the panel box. If this test shows that the circuit is clear up to this point, keep on opening and testing in this manner until the trouble is located.

Chief Electrician, EARLE N. DILLARD.
Booth-Kelly Co.,
Springfield, Ore.

* * * *

A. W. W. asks in the January issue why the fuses in one of his installations blow. He says in his description that the neutral in the transformer is grounded; so if there is not load enough on the circuit to blow the fuse, there must be a ground at times on the live side.

In a case of trouble which I saw recently a 100-watt lamp in an enclosed shade so heated the wires, which were rubber covered No. 18 fixture wires, that the rubber be-

came softened and through pressure either grounded or short circuited and blew the fuse. A smaller light caused no trouble. The circuit was less than normally loaded with the 100-watt lamp. Something of this sort may also be the cause of A. W. W.'s trouble. EDWARD A. GIBBS.
Boston, Mass.

* * * *

Preventing Corrosion of Iron Storage Battery Racks—I should like to ask your readers what treatment can be given to iron racks for storage batteries which will prevent the spilled acid from attacking the iron. We use the lead type of battery filled with dilute sulphuric acid. We have a large number of storage batteries and recently some iron racks have been constructed. All of these racks were painted with several coats of the best grade of asphaltum black paint but this does not protect the iron when acid is spilled on it, nor does any kind of paint that I have tried.

We have had considerable trouble due to the corrosive effect of the acid forming a substance resembling sand which falls into the jars below. This produces excessive iron in the solution, making a change of acid necessary. I shall appreciate it if anyone can tell me how to overcome this.
Atlanta, Ga. J. B.

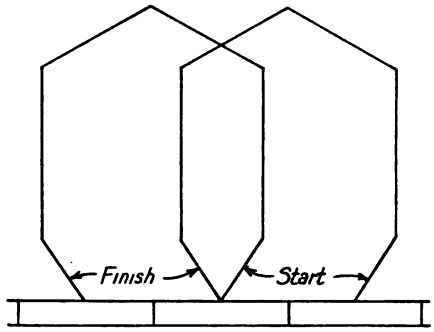
In answer to J. B.'s question in a recent issue of INDUSTRIAL ENGINEER, I have had good success in preventing corrosion of battery racks by washing them with strong solution of common baking soda and painting them, when dry, with a mixture of white lead and tallow. This procedure should be repeated as soon as corrosion begins to show again. EARLE N. DILLARD.
Chief Electrician,
Booth-Kelley Co.,
Springfield, Ore.

* * * *

Commutator Connections of Two-Pole, Compound-Wound Motor—I should like to see a diagram showing how to connect the starting and finishing ends of coils to the commutator of a two-pole, compound-wound motor, which is rated at ¾ hp., 220 volts, 3.7 amp., 1575 r.p.m. The coils have twenty turns of No. 22 s.c.c. wire. There are twenty-four slots, two coils per slot, and forty-eight bars.
Morrero, La. P. D. H.

P. D. H. asks in a recent issue how to connect the commutator leads of a two-pole compound motor. As a general rule, if the coils wind to the left the top leads throw to the left and the bottom leads to the left of the top leads. If the coils wind to the right, the leads throw to the right. If the coils connect to the left the finish lead of one coil connects to the start lead of the next coil to the left.

A compound-wound field does not

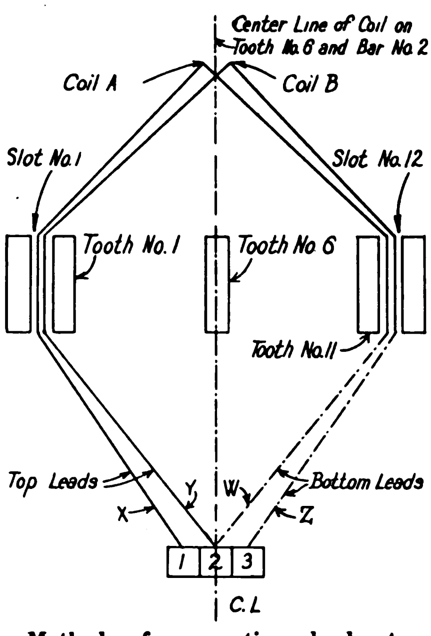


Commutator connections of two-pole, compound-wound motor.

affect the connections on the armature. P. D. H. speaks of using single-cotton-covered wire on the armature. It would be better to use either single-cotton-enameled wire or double-covered cotton, as single-covered cotton shorts easily.
Peoria, Ill. GEORGE RINGNESS,

* * * *

Referring to P. D. H.'s question in a recent issue, the diagram shows the method of connecting the coil leads to the commutator. The coil pitch is 1 and 12. To connect up the armature take any one coil and find its two top leads, as X and Y; then with a test light find the two bottom leads. Let W be the bottom lead of coil A, and Z that of coil B. Next, call the tooth to the right of slot 1, tooth No. 1. Count over to tooth No. 6, as shown, then take a piece of string and find the approximate center of tooth No. 6 and use this string to line out to the commutator on a line parallel to the axis of the shaft. Call the commutator bar this line falls on, No. 2; the bar



Method of connecting leads to commutator of two-pole, compound-wound motor.

to the left of this, No. 1, and the bar to the right of the line out, No. 3. Then put the bottom lead of coil A in bar No. 2 and the bottom lead of coil B in bar No. 3, as shown by the dotted line. Note that it is immaterial which coils are called A and B, as these are only indicated in the diagram to illustrate the method of locating the bottom leads. After these two bottom leads are in place, take the bottom leads from the next slot to the right and put one of these in each of the next two adjacent bars. Proceed in this way until all of the bottom leads are down. Then with a test light find the top leads as follows:

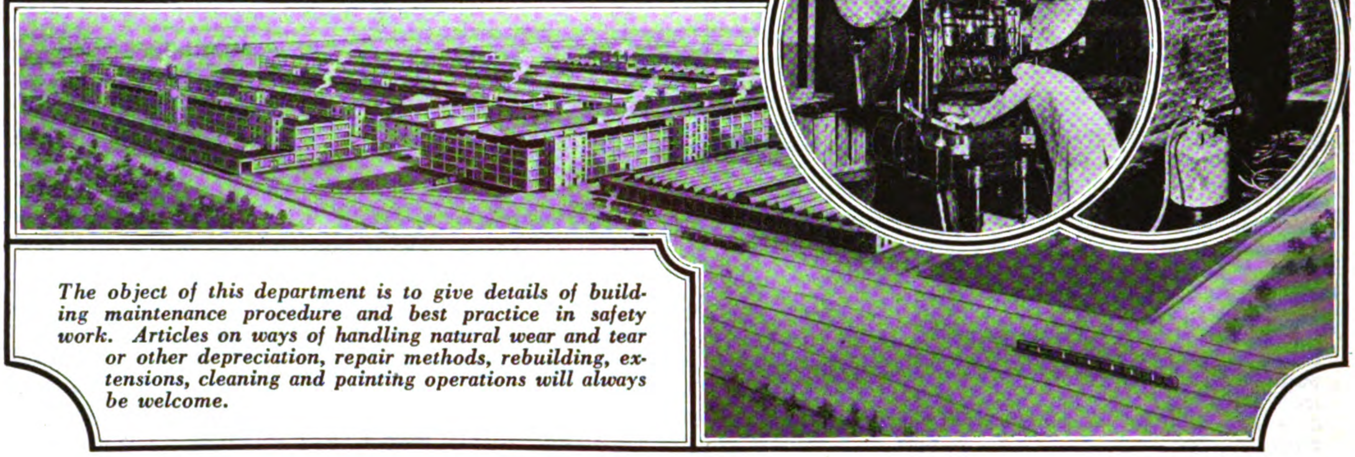
With one test lead on bar No. 2, find the top lead that lights and put this top lead in bar No. 1. Then put the test lead on bar No. 3 and find its top lead and put it in bar No. 2. Put the test lead on bar No. 4, find its top lead and put it in bar No. 3, and so on around the armature, working around in a clockwise direction for a left-hand winding. A winding is left-hand when the top or finishing leads are on the left-hand side, looking at the commutator end. For a right-hand winding, proceed in a counter-clockwise direction around the armature.
Detroit, Mich. A. C. ROE,

* * * *

Path Followed by Current in D. C. Generator—I wish some readers would show by a diagram the commutator connections and the path followed by the current in a direct-current generator which has two poles, 29 segments, 15 slots and 15 coils with a winding pitch of 1 and 4. The machine has two brushes set at 90 deg. I removed a short circuit from the armature of this machine and afterwards drew a diagram to trace the current. Owing to the winding pitch I failed to get the right direction of current flow for each coil. I have had considerable experience in winding d. c. and a. c. machines but this is the first time that I have seen a machine of this design.
Libby, Mont. J. Q. W.

In a recent issue of INDUSTRIAL ENGINEER, J. Q. W. asked for the connection diagram of a two-pole d.c. generator which has twenty-nine segments, fifteen coils and fifteen slots. From the description of this armature I believe that if he will examine the fields he will find that the machine has two field coils and four pole pieces, two of the pole pieces having no winding on them, but receiving their flux from the other two which are connected for the same polarity. A. SOULEN.
Warren, Ind.

Building Maintenance and Plant Safety



The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Red Spot on Wall Behind Fire Extinguisher Saves Priceless Seconds

As a result of familiarity through constant occupation of a shop the equipment for fire protection tends to become commonplace and out of mind, unless attention is focused upon it. One way of doing this is by means of bright signs. In a Connecticut factory the panels on the wall behind the extinguishers are painted bright red (red photographs black) as indicated in the accompanying illustration. In addition, the fire prevention rules, which tell what to do in case of fire, are mounted above the extinguisher. The eye inevitably "takes in" the extinguisher as it hangs in front of such a background as it is only necessary to look for the "red spot."

A red panel on the wall points out the fire extinguisher.

After workers have grown familiar with their surroundings through constant association their eyes may pass over a fire extinguisher in an emergency, unless it is made to stand out from its surroundings. The red background, if kept bright by frequent paintings, makes it easy to "spot" fire protection equipment even from some distance.

In the shop yard red arrows with signs indicate the location of the factory fire alarm boxes. These are also found helpful in locating this protective installation in a hurry. The red panels and arrows should be large enough so that they can be spotted from some distance. Frequent repaintings help to keep these spots bright and more easily seen in an emergency. H. S. KNOWLTON.

Boston, Mass.

How to Make Extension Handle for Lamp Changer

It is often necessary to replace or remove lamps which are mounted at a considerable distance from the floor, or in some location where it is difficult to place a ladder. In such cases the lamp changer is a useful device. In order to meet special conditions I made a telescoping extension for a lamp changer which further increases its usefulness and allows the work of replacing lamps to be performed with much greater safety to the workman.

The illustration shows how this extension was made. The lamp changer was forced onto a short length of ½-in. conduit, *A*. A 10-in. length of ¼-in. pipe was then attached to the piece of conduit by a rivet, *B*, which passes through both pipe and conduit. Then a piece of ½-in. conduit 10 ft. long, *C*, was slipped over the ¼-in. pipe. A coupling was sawed through on one side, parallel to its axis, and slipped over the upper end of the conduit. This coupling, as well as the conduit, was drilled and tapped for a ¼-in. setscrew, the coupling being used to give a greater thickness of metal to hold the setscrew.

When using the lamp changer the handle is extended to the proper length and the setscrew tightened; after using it the setscrew is loosened and the handle telescoped so that it can be carried more easily or stowed away conveniently until needed again. J. H. SAUVE.

Temiskaming Que., Can.

The lamp changer is mounted on a 10-ft. length of iron pipe which fits into another 10-ft. length of conduit and is held in place by a setscrew.

Practical Safety Don'ts for the Electrical Department

THE following list of safety dont's is multigraphed on an 8-in. by 11-in. sheet and furnished to the members of our electrical department. Before beginning work each new man is required to read and sign a copy.

REGULATIONS FOR THE ELECTRICAL DEPARTMENT

DON'T—Start motor before ringing signal bell, and waiting 15 seconds.

DON'T—Start a motor having a caution sign on controller before inspecting shafting or machine that motor drives.

DON'T—Use ladders without spurs.

DON'T—Use ladders with broken or dull spurs.

DON'T—Use broken ladders or any but regulation type.

DON'T—Use short ladders on boxes or blocks.

DON'T—Use ladders as supports for scaffolds or heavy weights.

DON'T—Work above machines in motion.

DON'T—Work on ladders in traffic aisles, alleys or runways without man on floor end.

DON'T—Work on poles, long ladders, high scaffolds or in boatswains chair if unfamiliar.

DON'T—Use metallic rules, tapes or metal-bound wood rules around live apparatus.

DON'T—Work near rope or belt drives in motion with any loose wire, hauling ropes, or loose-fitting clothes.

DON'T—Take any wiring or construction materials from storeroom without written order by Shop Attendant. Give him job number when ordering.

DON'T—Leave any supplies or waste material on job after completion. Return them to storeroom and give list to Shop Attendant to credit job with. This applies to both old and new material.

DON'T—Use solder melting or cable-splicing apparatus without having two fire extinguishers near at hand.

DON'T—Use any matches that are not of approved safety type provided by the company.

DON'T—Leave material of any description lying around job, on floors, boxes or shelves. Keep together in suitable receptacle. Violation of this rule is cause for dismissal.

DON'T—Lay tools or loose material on scaffolds, beams, overhead platforms or any place where liable to fall.

While these safety rules and regulations apply particularly to conditions in our textile mill they will no doubt also apply as well to the work of men engaged in the installation and maintenance of mechanical equipment for any mill or factory.

WILLIAM MCNALLY.

American Manufacturing Co.,
Brooklyn, N. Y.

Painting with Air Brush at One-Fifth of Brush Work Cost

RECENTLY a midwestern factory in enlarging its quarters found it necessary to repaint the interior of a building which had not been painted for several years. As time was an important element a portable paint spray outfit was purchased and one man put at work. The cost of air painting on this job was about one-fifth of the lowest estimate on what it would have cost by hand. The total saving amounted to several thousand dollars. In addition the compressed air forced the paint into all cracks and closed them up securely and permanently.

Removing Large Foundations With Dynamite

REMOVING concrete foundations by ordinary methods is a slow and expensive job. As in most cases this is rush work, other methods, such as the use of dynamite, sometimes offer opportunities to speed up the work and decrease the cost. For example, dynamite was successfully employed recently at a Philadelphia paint works to blast out a concrete pit which carried a set of track scales and was removed to make way for larger scales. The pit was about 65 ft. in length and its four walls were approximately 2 ft. in thickness and 10 ft. deep. It was also tied in at the bottom with heavy concrete cross sections.

The job presented some difficulties, because one of the side walls of the pit was about 2 ft. from a building with a number of windows. A similar building was located across the roadway some 20 ft. distant.

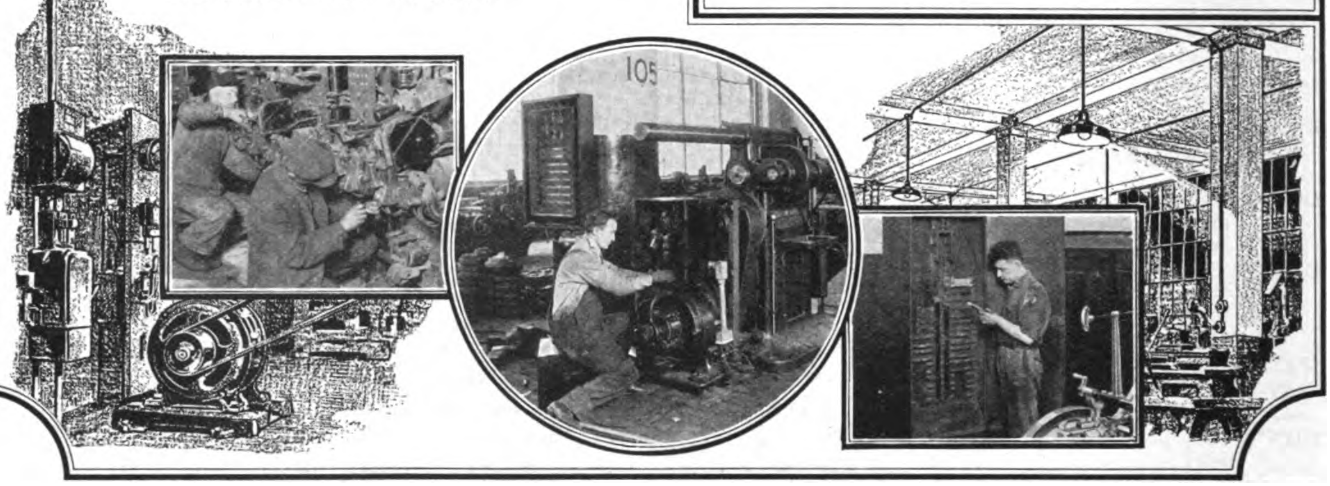
The cost of breaking up this pit by methods other than dynamite was estimated to be well over $1,000. It was successfully broken with about $15 worth of explosives and the time of one driller with a jackhammer air drill and of one blaster, who each worked less than three days. Successive charges of dynamite were placed at the proper points in the concrete and the walls broken down in sections. The shots were so gaged that no damage was done to surrounding buildings.

These two illustrations show the covering of the concrete pit foundation to prevent broken pieces flying about when blasting.

Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



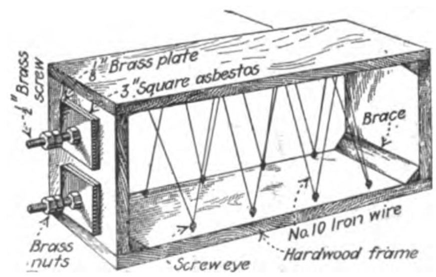
Electric Heaters for Drying Out Large Motor

At one time I served as electrician on a suction dredger whose centrifugal pump was driven by a 750-hp., 2,200-volt, three-phase, wound-rotor motor. Inasmuch as there was very little space between the motor and the other equipment, so that it was very difficult to make repairs, we took the best possible care of it in order to prevent a breakdown. The motor was, of course, in a very damp location and to avoid trouble from this source I made up several electric heaters for drying it out. These heaters were so easily and cheaply made and worked so satisfactorily that a description of them may be interesting.

As will be seen from the illustration the heater consisted of a hardwood frame, well braced at the corners, with loops of No. 10 iron wire supported by two rows of screw eyes in the two sides of the frame. Mica was placed under the screw eyes to keep the wood from charring. The ends of the resistance wire were connected to two terminals in one end of the frame. These terminals consisted of long, ½-in. brass screws, with the heads cut off, which were passed through brass plates ⅛ in. thick and 3 in. square. Two plates were used for each terminal, one on the inside and one on the outside of the frame. Under each plate was a layer of sheet asbestos to protect the wood of the frame.

The brass screws forming the terminal posts were held in place by locknuts on each side. In order to avoid the possibility of grounding, the holes where the screws passed through the wood were made considerably larger than the holes in the brass plates.

Power was delivered to the dredge at 11,000 volts through a submarine cable. Three delta-connected transformers were used on board, giving 2,200 volts. When in use the heaters were kept, for the sake of long life, at a "black heat," which meant that they had to be operated at 440 volts. When it was necessary to use the heaters during a shut-down, one of the transformers was disconnected, leaving the other two connected in open delta so that it was possible to operate the other 2,200-volt motors. The third transformer was then operated at 2,200 volts on the primary side, which gave 440 volts on the secondary for the heaters. Although this may seem like a cumbersome way of securing the proper voltage for the heaters, it was the best that we could do with the equipment available, and the transformers were so arranged that we could make the necessary changes either way in about 10 min.



The heaters were made by supporting loops of No. 10 wire on screw eyes in the two sides of a hardwood frame.

The rotor of the large motor had eight spokes and by turning it so that the spokes came in line with the braces on the end bells six heaters could be placed in the rotor. When the heaters were in place a tarpaulin was thrown over the motor, to dry it out and keep it dry.

San Francisco, Calif. S. H. SAMUELS.

Two Schemes for Controlling Lights From Two Points

The following comments have been received relative to a short article by P. Justus, which appeared under the above heading on page 99 of the February issue of INDUSTRIAL ENGINEER.—EDITORS.

* * * *

I noticed on page 99 of the February, 1924, issue a cut of hot-line 3-way switches in an article by P. Justus. In view of Rule 24, Section C of the 1920 National Electrical Code and Article 12, Rule 1204, Section A of the 1923 code, which states that, "Three-way switches shall be classed as single-pole switches and shall be so wired that only one pole of the circuit will be carried to either switch," I think there should be a note of explanation regarding this illustration, to the effect that the method of connection shown is not permitted under these rules.

Philadelphia, Pa. C. B. HUMPHREYS.

* * * *

On page 99 of the February issue there was a short article by P. Justus giving two schemes for the hook-up of 3-point switches. I would suggest that before any electrician attempts to install 3-point

switches according to Fig. 2 of that article, he had better consult Section 1204a of the 1923 National Electrical Code. This states that three-way switches shall be classed as single-pole switches and shall be so wired that only one pole of the circuit will be carried to either switch. While the practicability of work installed in accordance with Fig. 2 is all right, it might cause some embarrassment and inconvenience to the electrician installing it, if it has to be passed on by a local electrical inspector. W. C. GRUBB.
Auburn Junction, Ind.

* * * *

On page 99 of INDUSTRIAL ENGINEER for February there are shown two methods of connection for the two-location control of a circuit in which two 3-way switches are used.

It should be noted that the scheme shown in Fig. 2 is prohibited in Rule 1204a of the 1923 National Electrical Code, which specifies that, "Three-way switches shall be classed as single-pole switches and shall be so wired that only one pole of the circuit will be carried to either switch."

Hence, the wiring shown in Fig. 2 should never be employed in installations that are subject to the jurisdiction of electrical departments which follow the National Electrical Code. It is a fact that the wiring method of Fig. 2 has decided advantages for certain conditions and that it may also, under certain conditions, be much more economical of material than that of Fig. 1.

Our feeling here is that the method of Fig. 2 is entirely safe and often justified. However, it has the disadvantage that it reverses the polarity of the socket shells; this conflicts with the 1923 Code ruling which specifies that the shells of all lamp sockets shall be connected to grounded wire. TERRELL CROFT.
Directing Engineer,
Terrell Croft Engineering Co.,
St. Louis, Mo.

Simple Brake for Testing Motors Up to 100-Hp. Rating

A BRAKE which was built in a New Jersey shop for testing motors up to 100-hp. rating, gives very accurate results. Bands of automobile brake lining pressing on a steel pulley give the braking effect. One end of these bands is attached to a wooden scale beam which is balanced by means of iron weights. There are two main 4-in. belts passing up and three-quarters around the pulley, where they are connected to a 2-in. belt, the end of which is fastened by a wire to a small spring scale. The brake lining is of asbestos interwoven with brass or copper wire and stands the heat well. In order to lessen the friction, maple-wood strips are inserted between the band and the pulley. The construction of the brake is shown in the illustration.

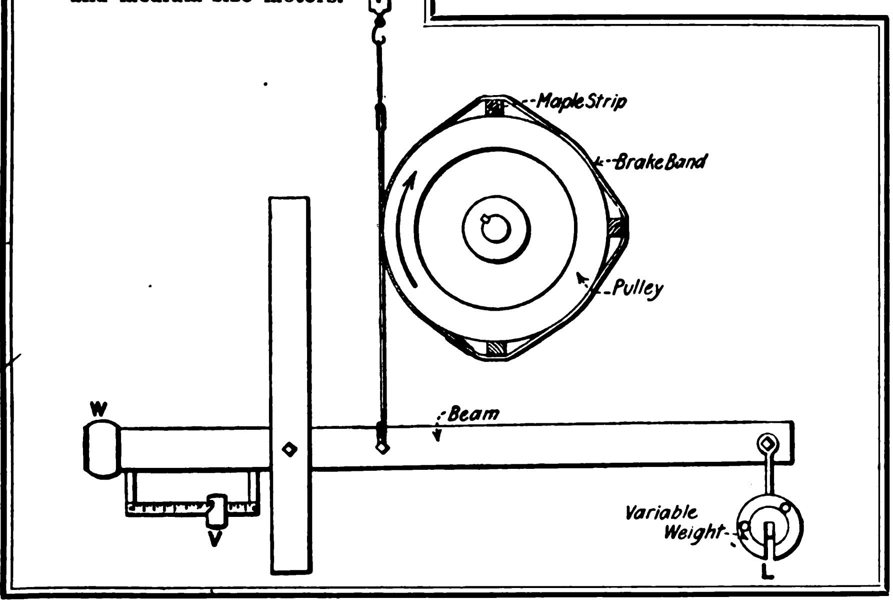
In making a test, after the belt is placed around the pulley the beam is balanced by means of the sliding weight V. As the motor is brought up to speed the belt tends to lift the beam. To put different loads on the motor the weight L is changed. The beam is so proportioned that 1 lb. at L will give a pull of 5 lb. on the belt. The pulley shown has a diameter of 25.2 in. and a 12-in. face. With a pulley of this diameter twice the net pull in pounds multiplied by the revolutions per minute and divided by 10,000 gives the horsepower directly. This pulley may be used for any torque up to 300 lb.-ft. A 12.6-in. pulley is used for measurements up to a torque of 100 lb.-ft. To prevent the pulley overheating it is flanged so that it will hold water during a test.

Care must be taken to prevent the belts jamming around the pulley and tearing loose, with possible serious damage. The best results are obtained when the spring balance pull is about one-tenth of the main belt pull. The net pull, which is used to calculate brake-horsepower, is the pull on the main belt minus the pull on the spring scale.

The bearings of the scale beam are carefully lined and are babbitted. The arm is counter-balanced for its own weight and that of the belts and fittings by weight W and the sliding weight V. The frame of the brake must be strong enough to stand an upward pull of 1,000 lb.

Chief Tester, F. W. GAY.
Crocker-Wheeler Company,
Ampere, N. J.

Construction details of brake for testing large and medium-size motors.



Use of Aerial Power Cables in Industrial Plants

AERIAL power cables suspended from a messenger attached to poles or other convenient supports are worthy of careful consideration by the engineer who is responsible for an assured continuous supply of power for operating machinery. Central station companies are gradually coming to use multiple conductor cables in this way and many of the reasons which make this good practice under certain circumstances also apply to large industrial plants.

In the first place open wires for high-voltage circuits are dangerous in congested locations unless very expensive construction is employed. Furthermore, interruptions of service are quite likely to occur with open wires. Aside from the possibility of insulators breaking down and damage from sleet and wind, there is always the liability of some injury by traveling cranes handling an unusually large object or by accidents from entirely unforeseen causes. Strange and unexpected things happen in plants engaged in heavy operations. In a steel plant where the wires were carried on a bracket structure attached to the side of a long building, they were

put out of service every once in a while by an avalanche of snow sliding off the high sloping roof. An aerial cable has been substituted for the open wires and since that time there has been no trouble. Another place where this practice proved beneficial was where a 6,600-volt circuit passed under a coal hoist; in this case the cable was protected by steel wire spirally wound over the lead sheath, similar to a submarine cable.

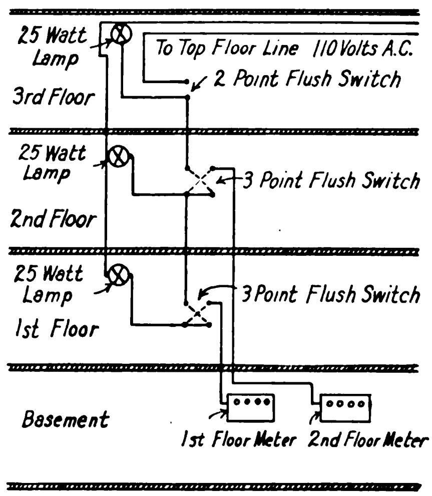
Of course, trouble may be practically eliminated by underground construction and this is employed in many cases but it is expensive and rarely pays except where an entirely new plant is being laid out. In old plants where electrification of the various machines is gradual and piecemeal, the wires are usually attached to poles, roofs, or brackets on the sides of buildings. It not infrequently happens that it is economical to have 6,600-volt circuits for motors of 150 hp. or over or for tying in substations with each other and with the generating station, if there is one, and it is in such cases that it is good practice to use cables. Examples of this method have been observed in steel mills, one of which has nearly two miles of it, as well as in other industrial plants.

The objection may be raised that cable is more expensive than open wires. This is undeniable but it is equally undeniable that the maintenance and depreciation are so much less as to be almost negligible. Practically everyone who has used aerial cable says that there is never any trouble and they forget that they have a cable. But the most important advantage of cable from the practical standpoint is the almost complete assurance of continuous service. In many of the operations in the steel industry, for instance, the value of the material in process of manufacture is so great and the damage to materials and loss in operating efficiency so serious in case of accidental interruptions of power that it pays to spend money on equipment that will eliminate or substantially decrease such troubles. In fact, the attitude of the electrical engineers responsible for the supply of electrical energy is shown by the fact that in the two steel mills mentioned these men regularly install cables designed for double the operating voltage actually used in order to increase the factor of safety. As both of them have expressed it, the comparatively small increase in the first cost of the cable is insignificant when compared to the great importance of delivering energy where and when it is wanted.

New Canaan, Conn. F. A. WESTBROOK.

Method of Wiring for Lights at Stairway

RECENTLY it was necessary to place a small lamp on each rear landing of a three-family tenement building, which was the property of a large manufacturing company, long after the building was completed. Inasmuch as no one family was to bear all the expense of the lighting and there was no special meter for this service, it was decided to arrange the wiring so that each tenant could switch onto his own meter the lamps on the floors below him. Thus, if the third-floor tenant desired a light his switch would light the lamps on all three floors through his meter. Each tenant could thus light his own lamp and all those below him, but none above him.



Arrangement of wiring so that the switch on each floor will light stairway lamps on all floors below, but not above.

The lamps used are only 25-watt rating, but they were wired as described in order to avoid any imposition. In other words whoever switches on, pays.

As will be seen from the illustration the top floor switch was wired to the top floor line for a meter connection, but the first and second floors were wired to their respective meters in the basement, as the lines in the ceilings could not be reached. The wires from the power supply direct to the switches must be on the same side of the circuit.

In reality the job was simple enough and was done by one man in 12 hr. at a cost of about $10.

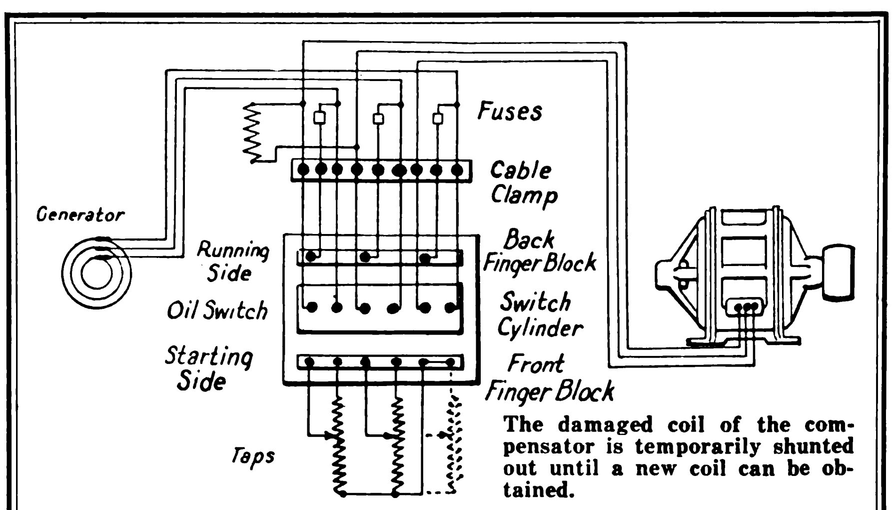
New Britain, Conn. H. S. RICH.

Method of Starting Motors With Damaged Compensator

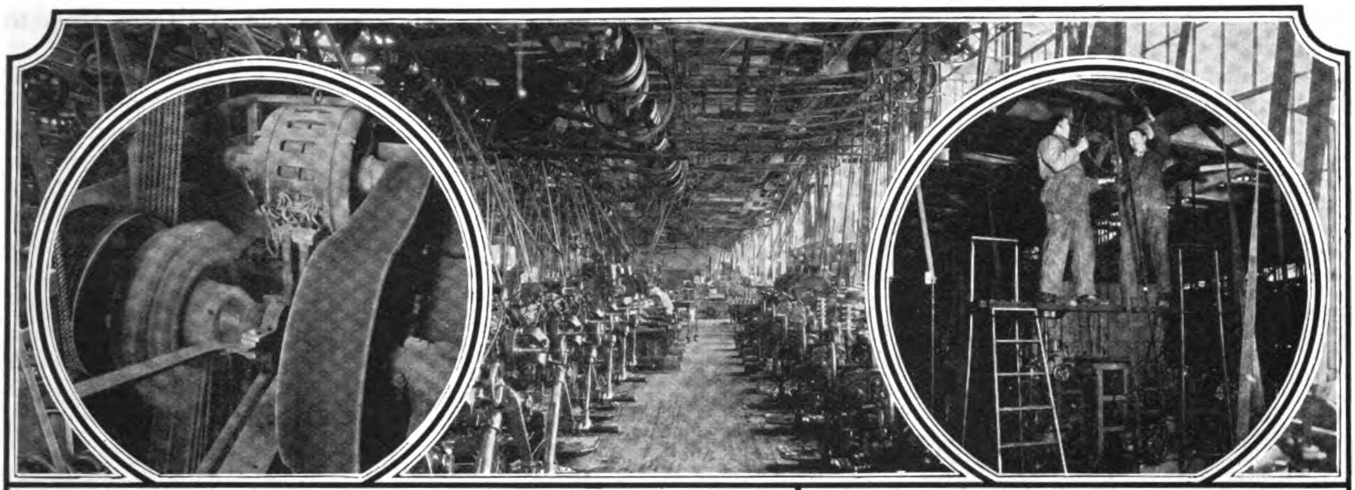
IN a large industrial plant where a large number of 2,200-volt three-phase induction motors are in use, these have been started with entirely satisfactory results when one coil in the starting compensator was cut out as shown in the accompanying illustration. Spare coils are carried in stock for all of the larger compensators, but occasionally a coil burns out that can not be repaired or for which no replacement is available. When this occurs the damaged coil is disconnected and jumpers are placed as shown. While this is, of course, an emergency method of maintaining service it has always given good results, until a new coil could be obtained.

FREDERICK KRUG.

Comerio Falls, Bayamon, Porto Rico.



The damaged coil of the compensator is temporarily shunted out until a new coil can be obtained.



Mechanical Maintenance of
Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

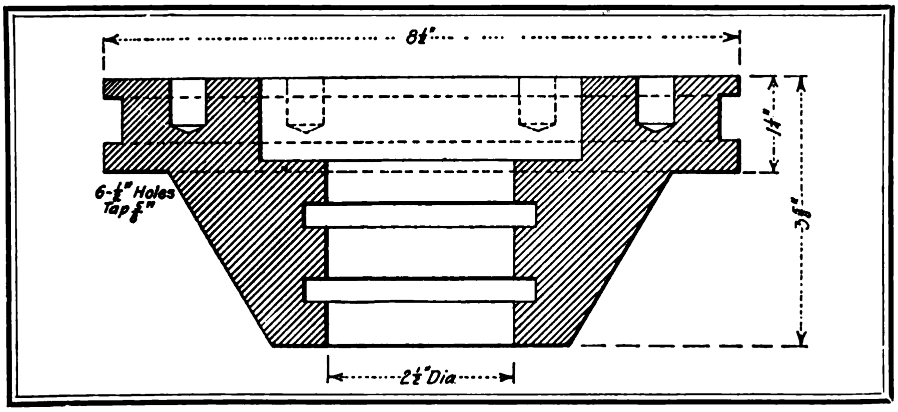
Trouble Reduced by Use of Ball Bearings on Mine Locomotives

OWING to trouble with the brass-lined bearings on the motors of mine locomotives, J. C. Kendall, Hancock, Mich., reports that the Quincy Mining Company (Mich.) found it necessary to replace these bearings with ball bearings. The trouble was due to the armature heating up at times of overload and melting the grease out of the bearings. With no grease in the bearing the shaft would cut the linings out and allow the armature to drop down on the pole pieces. To remedy the trouble it was decided to try ball bearings; so the bearing caps shown in the illustration were built to replace the old caps.

To prevent the ball race from turning on the shaft a jam nut is tightened against it on the pinion end of the shaft. On the commutator end a washer and cap screw perform the same function. The bearing shown in the sketch is for the pinion end, the one for the commutator end being slightly smaller.

Sixteen two-motor locomotives with sixty-four bearings were changed in this manner some time ago, and since then no bearing troubles have been experienced.

Bearing caps like these were used when brass-lined bearings were replaced by ball bearings on the motors of mine locomotives.



Change in Grade of Oil Cause of Bearing Failure

AN INTERESTING case of lubrication trouble came to the writer's attention recently on the motor end of a flywheel motor-generator set, (3,000 hp., 505 r.p.m., 2,300 volts) which supplies the d.c. power to the main drive motor of a reversing blooming mill. During the regular overhauling at the week-end, the oil was drained from one of the bearings of the motor, and the oil basin cleaned out and filled to the proper level with clean oil. On Monday morning the motor-generator set was started as usual and the bearings were given the customary inspection to see that the oil rings were running freely and carrying up oil. About two hours later it was noticed that the bearing in which the oil had been changed, was heating. Preventive measures were taken but before they became effective the babbitt melted and the shaft dropped. The motor was stopped before any damage was done to the rotor.

After considerable trouble the motor shaft was jacked up, the pedestal removed and the bearing taken out. Inspection disclosed no dirt or other foreign matter, either on the shaft or in the oil.

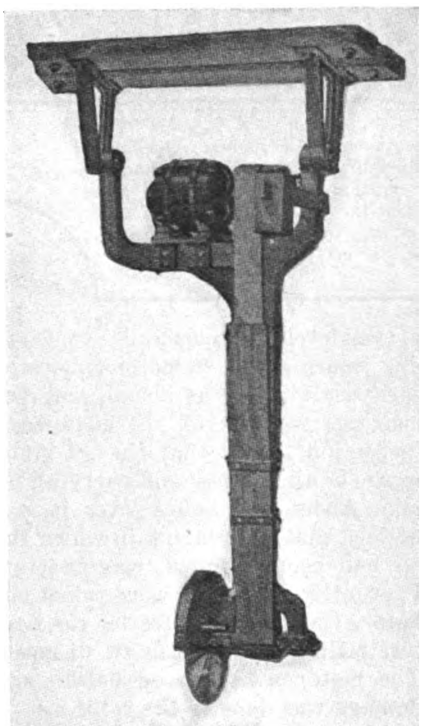
Examination of the oil showed that it was of a somewhat lighter grade than was formerly used. It was found that because of a difference in price an oil made by another manufacturer and which was said to be of the same grade as the original oil, was bought by the purchasing department. The storeroom gave the maintenance man this oil for use on the machine and no mention was made of the change of manufacturer. The trouble encountered proved that the oil was not of the same grade and was not suited to the needs of the bearings on this machine.

A new bearing was put in the motor and the original grade and make of oil was substituted for the oil in question. No further bearing trouble was encountered on this machine. In the writer's opinion changes should never be made in the grade

or make of oil used on important drives until careful tests have shown that the new oil is suited to the service requirements. U. A. J.
Chicago, Ill.

Individual Drive for Swinging Frame Cross-Cut Saw

FOR driving a swinging-frame cross-cut saw, an industrial plant in Connecticut has adopted the method illustrated of mounting the



Mounting the motor on the cross-frame of the saw was a convenient way of obtaining individual drive.

motor directly on the cross-frame of the saw. The motor is served from a wall outlet just back of it, the conductors being coiled to allow swinging of saw. In order to protect the operator from injury the belt is incased by a wooden guard, as shown in the illustration. The motor is controlled by means of a 30-amp. C. R. General Electric push-and-pull switch mounted near the operator.

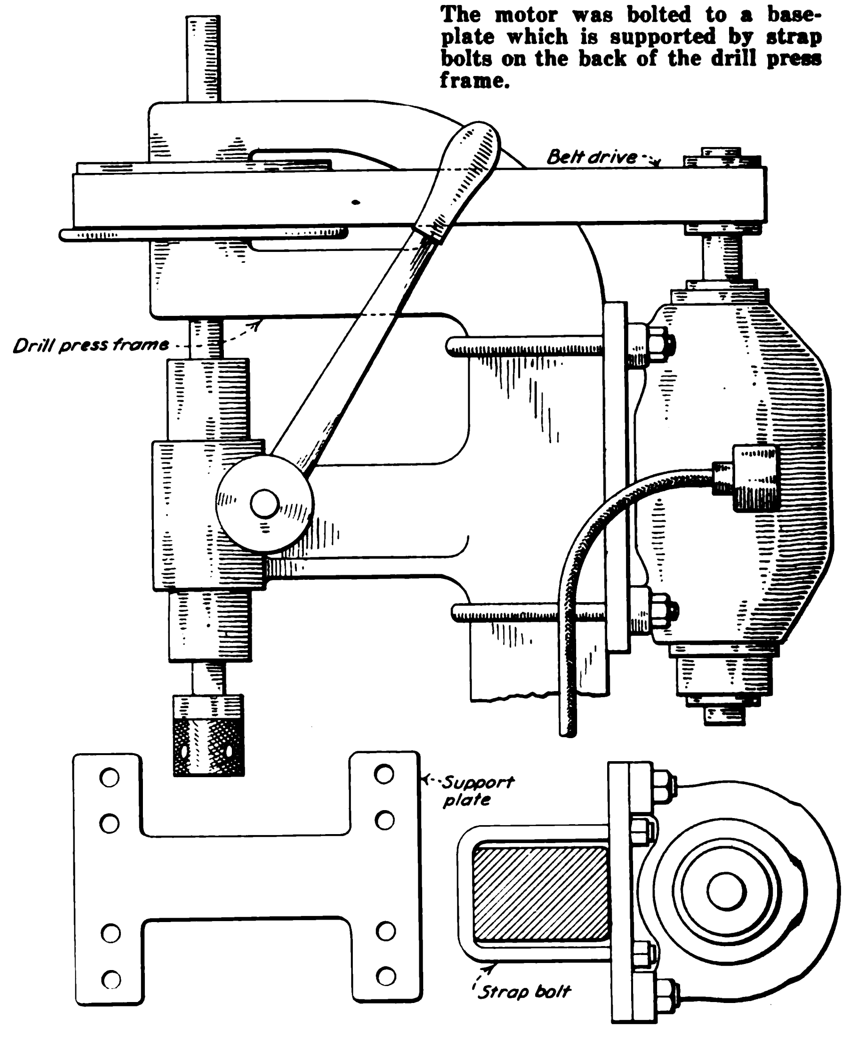
Application of Direct Drive to Drill Press

IN ONE SHOP where the various items of machine shop equipment were driven from a lineshaft, it was desired to avoid the necessity of driving the entire line of shafting and pulleys to operate only the drill press which was, as usual, the most frequently used piece of equipment.

The adoption of direct motor drive was decided upon; after consideration of the possible methods of mounting the motor it was decided to mount the latter in a vertical position, as shown in the illustration. For this purpose a simple form of strap bolt was made to encircle the drill press frame at the back and support a baseplate to which the motor was securely bolted. A direct belt drive to the spindle was then possible, without the use of intermediate pulleys or shaft.

This motor has been operated vertically for more than a year and the installation has proven to be very satisfactory, although there was some apprehension at first that the bearings would not stand up. While it was the original intention to place a small thrust-plate directly under the armature shaft, this has not been found necessary as the interior thrust bearings in the motor are adequate for the weight of the armature. G. A. LUERS.
Washington, D. C.

The motor was bolted to a baseplate which is supported by strap bolts on the back of the drill press frame.

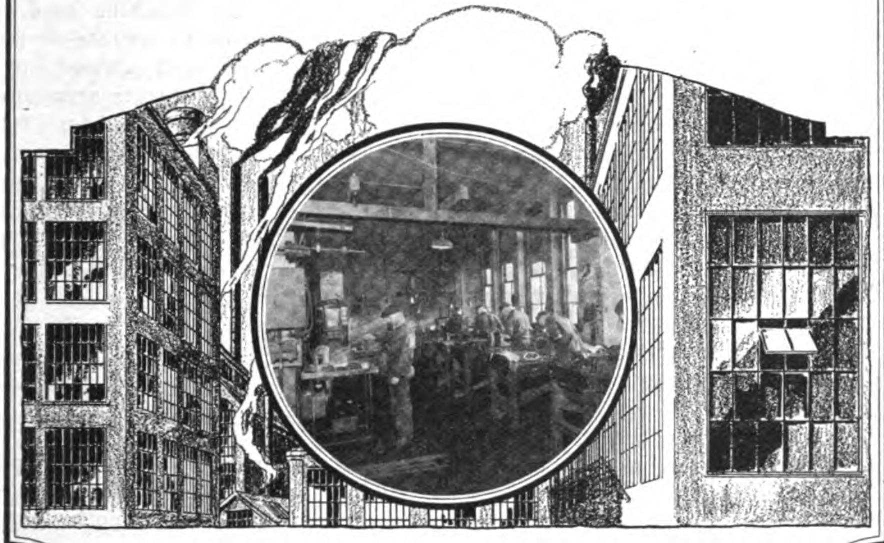


How an Uneven Belt was Made to Run True

THE defective portion of the driving belt of a high-speed, three-bearing generator was recently removed and replaced by a new piece. When the machine was started, following the repair, the belt persisted in running off to one side, bringing one edge in contact with the outboard-bearing pedestal of the generator. As a result, the edge of the belt became stretched and worn and began to flare out.

The difficulty was overcome by transferring the crown of the pulley from the middle of the pulley face to a point nearer the center bearing. A ring of 1/8-in. holes was drilled around the pulley face at the place it was desired to have the new crown and a strip of rawhide belt lacing riveted in place. After this the belt ran true, as the effect of the new crown was to force the belt to the center of pulley. A. J. DIXON.
St. Louis, Mo.

In the Repair Shop

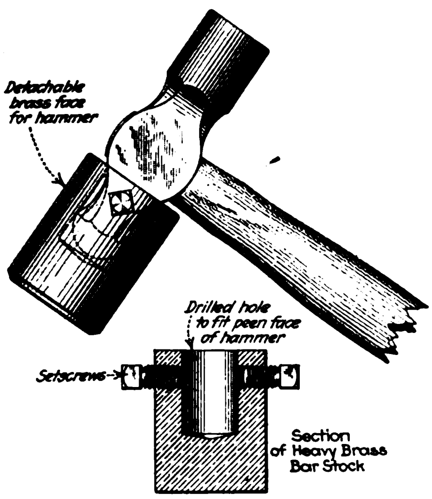


This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Brass Face for Hammer Reduces Weight of Kit

THE brass hammer is a very useful tool for pounding on parts which would be injured if the ordinary machinist's hammer were used. However, it is one of the heavy tools of the repair kit and if both it and a machinist's hammer must be carried the weight of the kit is considerably increased. The method which was adopted by one repairman to keep down the weight of his kit is shown in the illustration. As will be seen he made the brass face as a detachable part of his hammer.

This was done by drilling a short piece of heavy bar stock for a close fit over the peen head of the hammer; two holes were then drilled and tapped for setscrews to hold it in place.



The brass face for the machinist's hammer is made by drilling heavy bar stock to fit over the peen head and providing set-screws to hold it in place.

When the brass face is attached to the hammer, driving work is accomplished with the same facility that is provided with a solid hammer. When detached the brass face can readily be stowed in the kit without adding any appreciable extra weight.

Washington, D. C. G. A. LUERS.

Two Repair Shop Experiences That Taught Lessons

SOME TIME ago, when making repairs outside of the shop, we were working on an elevator whose reversing switch repeatedly burned out the contacts. On this switch the armature and shunt contacts broke the connection at the same time; the armature contacts had a sharp, snapping spark to them. When the shunt fields were connected across the lines permanently, the armature contacts barely sparked when the machine stopped. We then put the field leads back where they belonged and put a suitable resistance across the field leads to take care of the field discharge and the switch has operated satisfactorily for several years.

When relating my shop experiences, I may as well give one of our prize mistakes in the hope that it will prevent some other repairman from doing likewise. This happened when we changed the throw of the coils on the armature of a Westinghouse interpole motor. The plant first sent in the armature alone to be rewound. The armature had fifty-nine coils and was wound 1-16. This checks out 1-16-31-46-61, or two past the number of coils. Before this, we had always thought that if the throw did not come out even it was better to wind it under rather than over. As 1-15 came out 1-15-29-43-57 we wound it 1-15 without changing the throw of the top lead or the span of the bottoms from the top.

When the armature was put back into service it ran all right under no-load, but sparked and ran hot under load. The entire motor was then sent into the shop and we found that by shifting the brushes we could reduce the sparking but not the heating. We then wound the armature 1-16 and the machine has run fine ever since. Evidently the Westinghouse Company must set their brushes by the throw of the bottom lead. We also found that it does not pay to change the throw of the coils from the factory span.

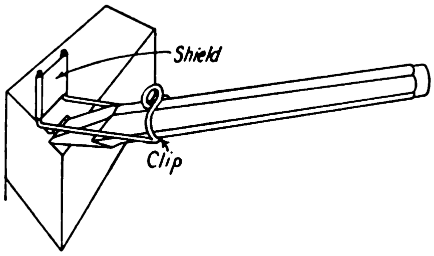
I hope these experiences will be helpful to some of the other readers and would like to get some of theirs.

Peoria, Ill. GEORGE RINGNESS.

Shield for Chisels Keeps Chips From Flying

MANY times when using a chisel we want to keep the chips from flying, when the metal is worth saving or the chips will annoy other workmen or get into electrical equipment. The accompanying drawing shows a shield that can be applied to chisels to keep chips from flying about, save windows and keep workmen from complaining about "the other fellow."

The clip is made of piano or other spring wire formed so as to grip the chisel. The shield is made of thin sheet stock, with the ends curled to slip over the bent-up portion of the clip. The clip can be slipped back and forth on the chisel



A piece of spring wire is bent to form a clip which grips the chisel and supports a thin metal shield.

to get the required distance, and bent to get the proper height of the shield. When grinding the chisel the clip may be slipped back out of the way or removed entirely. By making a fair-sized loop the clip will have sufficient spring to enable it to be used on several sizes of chisels.

Detroit, Mich. NELSON HALL.

Rewinding 44-Volt Generator to Give 1,000 Volts

NOT long ago I received a call from the officer in charge of a government radio station to come out and look over a generator with a view to making some changes in it. I was much elated over the prospect of adding this station to my list of customers, but upon arrival and being shown the machine and the nature of the proposed changes my elation was, for a time, suddenly changed to something else.

The proposed changes involved not only a rewinding job but also a re-designing job, due to the fact that the new voltage was to be many times that for which the machine was designed. At the outset it was apparent that design procedure should be reversed, in that it would be most expedient to make the armature fit in with the fixed field conditions. The original rating was 44 volts, 22.5 amp., 1 kw., and the problem was to convert this machine into a generator that would deliver 0.5 amp. at 1,000 volts. The machine was an old one with a smooth core armature, four poles and 121 commutator bars. The armature core was 6 in. in diameter and about 6 in. long. The commutator was approximately 4½ in. in diameter, making the bars quite small.

After stripping the armature it was sent to the machine shop to have thirty slots milled in it. It came back with the job done perfectly. Work was then started on the commutator—the real seat of all the trouble. Every fourth bar was removed and then three bars were connected together to form one bar. This gave us thirty bars for the new winding. The necessary precaution was taken to reinforce the commutator and brush stud insulation and the armature was then ready for the new winding. Because of the large number of turns per coil (110) we took no special precautions with the coil insulation, as the voltage per turn was low and the coil voltage was also comparatively low. The co-efficient of self-induction was also about as it was with the old winding, due to the lessened current output.

The procedure that really made the work successful was this: By removing every fourth bar the distance between bars was made great enough to prevent flashover. At the same time, the period of commutation was kept about the same as before; in fact the period was less with the new winding.

After the winding had been put on the space between the bars was filled with a mixture of powdered mica, glue and plaster of paris of the right proportion to give it about the same wearing rate as the bars. The winding was then heated and dipped in air-drying varnish, the commutator was turned down and the winding was tested with 3,000 volts alternating current for one minute. The commutator was tested between bars with 350 volts. These tests being passed satisfactorily, the machine was ready to be given the trial run.

The generator was equipped with four brush studs, but only two brushes were in place and I was just a bit dubious about trying it under these conditions, because I realized that with the other brushes in place on the commutator the commutation would be much better. However, it was started up with no load and with a little more than half of the field resistance in and the voltmeter reading about 700, the region between the two brush studs was a solid mass of fire. This was found to be due to two causes: Due care had not been exercised in removing the dust after the brushes had been fitted; also the two brushes were collecting too much current at this voltage. With a clean commutator, and the other brushes in place the machine was started up and the voltmeter showed about 1,200 volts with only an occasional faint spark at the brush tips.

A long message had been prepared, as a test, to be sent to another station and when the machine was connected to the sending apparatus, with less field than was used in the trial run, the pointer of the ammeter connected in the antenna circuit went off the scale. The sending of this message consumed about one hour and fifteen minutes and inasmuch as the generator hummed along with practically no more sparking than on no load, we assumed that it was all right, which assumption has proven to be correct after more than a year of continuous service. It is interesting to recall in this connection, that the manufacturer of this machine said it could not be made to operate at the potential desired, and advised buying one with two separate armature windings, each designed for 600 volts.

All of which goes to show that when one of those "impossible" jobs comes along, it pays to give it a trial. D. L. WAYNE.

Chief Electrician.
Prairie View State College,
Prairie View, Texas.

Easily-Made Hacksaw Frame for Heavy Work

THE ordinary hack-saw frame can be purchased so cheaply that generally there is nothing to be gained by making one yourself. However, the one described below is much stronger than the very cheap types and the knowledge of how it was made may help someone who wishes a stronger hack-saw frame than the ordinary type, or who has the time to make one.

The frame was made by bending to the proper shape a piece of ½-in. wrought-iron pipe about 20 in. in length, the radius of the bends being about 3 in. This left a frame like the letter D, except for the front vertical line, the end pieces being 4 in. or 5 in. in length and the back about 13 in. long.

A ¼-in. hole was drilled through each end of the pipe. In these holes were pieces of steel rod, square in section between the frame and the saw, but threaded on the portion which went through the holes in the frame. On one end of one of these rods there was an ordinary hexagon nut to hold it in place. The part of the other rod which went through the frame was fitted with a wing nut and had a much longer thread than was cut in the one on the other side.

In the square ends of the rods small holes were drilled and pins, made from nails, were driven into them tightly and the end of the nails cut off. This left short projections onto which the ends of the saw were hooked; after the saw was in place it could be drawn up tightly by means of the wing nut on one of the rods.

There was no handle, as the user was expected to guide the saw by means of the vertical ends.

Westfield, N. J. G. H. McKELWAY.

Applying Insulating Varnishes

(Continued from page 186)

and along with it any oil that may still remain. If the armature is to be stripped, scrubbing with a wire brush as soon as the armature is removed from the washing tank will take off all the old varnish from the surface and render the removal of the coils much easier.

If the gasoline in the washing tank is allowed to stand after use for some time, the dirt and some of the oil will sink to the bottom and can easily be drawn off, leaving the remaining gasoline fit for use once more.

As many additional coats of the baking varnish may be applied as is thought necessary, bearing in mind that for protection against moisture, oil, etc., a perfectly continuous coat is necessary. Cracks or breaks in the continuity will permit oil, moisture and conducting particles to enter the coil, with disastrous results as far as protection against shorts or grounds is concerned. Fibrous insulation, such as cotton, has many stiff hair-like fibres that tend to pierce the varnish film. When they do they act like wicks and tend to draw moisture and oil into the interior of the coil by capillary attraction. These fibres must be completely covered. Because of lack of time and production expense it is not always practicable to apply five or six coats in the manner described above; hence the results desired are approximated by applying as many baked coats as possible and then following with one or more applications of air-drying varnish to obtain the continuity of film.

Application of Brushing and Spraying Method

These air-drying or finishing varnishes may be applied by either brushing or spraying. If the brush is used special care must be taken. It is best to apply liberally at first and then, after squeezing the excess varnish from the brush, go over the whole surface with a thin coat, smoothing it down until a good, even film is obtained. Even with the greatest care, however, some parts are very likely to be overlooked.

It is not wise to depend upon brushing for the entire treatment of coils. It is impossible by this means to force the varnish into the interstices where insulation is most needed. Hence brushing is recommended for cases where surface protection only is required.

The Air Spray.—Spraying is considered preferable to brushing. The work can be done evenly and quickly. It does not, however, insure the complete filling of the coil and hence it is advised only for the finishing applications as an alternative for the brushed coat. It uses a little more varnish that when the hand brush is used, because heavier coats are applied. The expense of application, however, will be no more because of the saving in time and labor required for treatment of a given piece.

The spray is simply an air brush in which compressed air forces the varnish out through a nozzle in a very finely divided state. Much of the solvent is evaporated between the time the varnish leaves the nozzle and the time it strikes the work. Hence it will be found that the varnish film dries much faster than in any other application. In spraying large pieces such as complete stators, by the time the first coat has been completely put on, the surface where the start was made is dry enough for a second application. Thus very thick coats can be built up in a comparatively short time.

Before selecting a sprayer the amount of work to be turned out per day should be determined, as well as the size of the largest piece to be treated. Then consult a reliable manufacturer of varnish air sprayers, giving him at that time the maximum air pressure available in your shop. Nozzles with adjustable size openings are the best, as they may be adapted to the particular kind of varnish used. An air transformer set to remove dirt, moisture and oil from the compressed air, together with the connections and proper exhaust arrangement, should be installed at the time the sprayer is put in. The exhaust equipment consists of a hood connected to the outside air with a suction fan to draw the fumes and vapors away from the room.

When through using the sprayer for the day, it should be thoroughly cleaned, particularly the nozzles, taking care that no partially dried varnish remains to clog the openings. The thinner used for the varnish is entirely suited for this purpose.

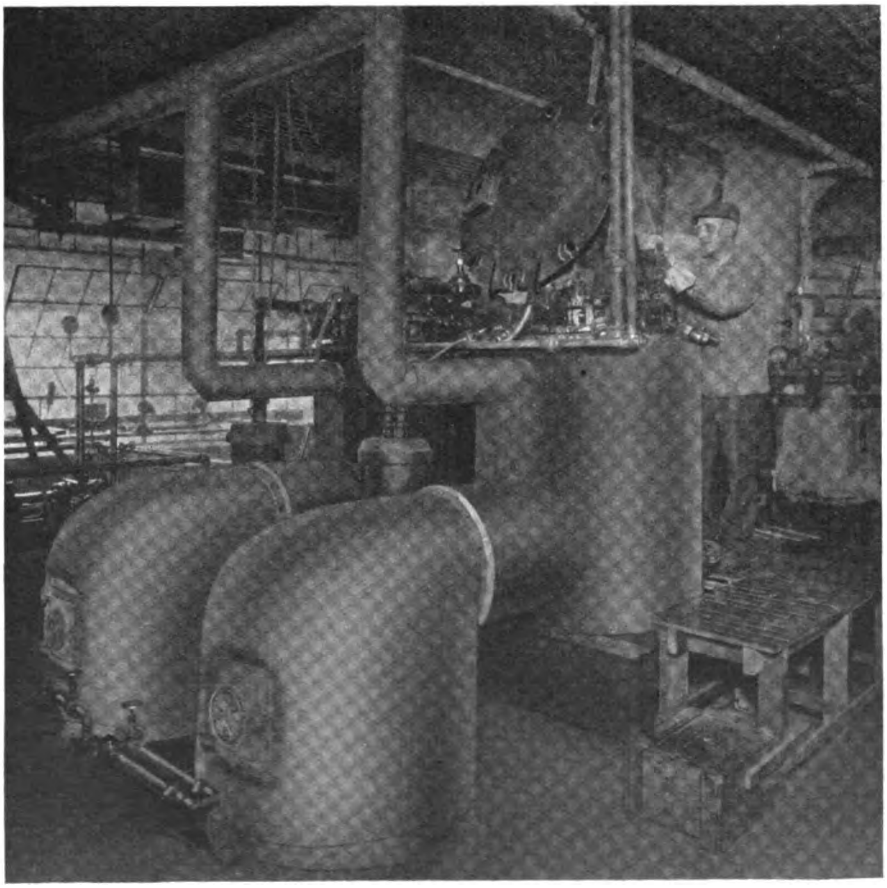


Fig. 5—Vacuum pressure impregnation outfit in shop of Atwater-Kent Manufacturing Co., Philadelphia, Pa., as made by the Buffalo Foundry Machine Co., Buffalo, N. Y.

In some shops where no oven is available and where dependence is placed upon the brushing or spraying method, it is the practice to dry the coils by passing an electric current through the windings. This has the advantage that the varnish is dried first inside the coil without the formation of a surface skin. Hence thorough drying is obtained throughout. It is, however, costly and therefore not economical when an oven is available.

Principles of Vacuum-Pressure Impregnating Method

Still another method of applying insulating varnish to coils is by means of vacuum-pressure impregnation. Suitable sets for this purpose can be purchased outright. They consist of a storage tank for the varnish, a pressure tank that can be sealed so that no air can get in or out, and a vacuum pump.

The coils to be treated are placed in the pressure tank and heated to about 220 deg. F. All valves are closed except that leading to the vacuum pump. The pump is started and run slowly for from 1 hr. for small coils to 4 or 5 hr. for those of large cross section. This process removes all occluded air and moisture from the interstices of the coil. That is, it simply takes the place of the preheating of the work in the dipping system.

At the end of this time the heat is reduced to about 70 deg. F. and the best vacuum possible is drawn. The valve to the storage tank is then opened, without breaking the vacuum, and sufficient varnish is drawn into the pressure tank to completely cover the pieces. The valve to the storage tank is then closed and the pump stopped, after which air is let in through the valve at the top until atmospheric pressure is reached. This valve is next closed and the pump started in the opposite direction so as to create a pressure of about 15 lb. This is maintained for from ½ hr. to 5 hr., depending upon the structure of the coils and the viscosity of the material used. Then the valve to the storage tank is opened with the pressure still on but reduced to that just sufficient to force the varnish out of the pressure tank. When the material is all back in the storage tank again, the valve is closed and the coils taken out. They will be found to be well drained but should be allowed to stand for at least an hour at room temperature so as to allow the varnish to partially set. They should then be baked in exactly the same manner as has been described in the dipping and baking method.

In general this method is altogether too expensive in comparison with the results obtained for ordinary use. Simple dipping will produce like results provided that it be remembered that a longer time is required to completely fill the interior of the coils.

The process is, however, the only one that will give satisfactory results when solid compounds are to be used instead of the varnish. These compounds have the advantage that there is no solvent to evaporate and hence they completely fill the coils in the first application. It must be remembered, however, that they resoften under heat and are therefore, unsuited for the treatment of those coils which are subjected to extremely high temperatures, or for the treatment of moving parts where the soft compound is likely to be thrown out by centrifugal force.

The operation of the impregnation set is the same for compounds as for varnish except that the storage tank must be provided with heating coils capable of bringing the compound up to a liquid state. These heating coils should be placed in such a position that the compound is heated from all sides at the same time, rather than applying a very high temperature to the bottom of the tank. If this latter is done the compound at the bottom becomes liquid while that at the top is almost solid and an eruption is quite likely to follow. Also, the temperature of the pressure tank must be maintained throughout the entire operation at that which is required to keep the compound in the liquid state. Generally the pressure required to force the compound into the coil should be at least twice that required when varnish is used.

As the compound is repeatedly heated and cooled the temperature at which it liquifies gradually rises until a point is reached where it is impracticable, if not impossible, to melt it. Before this time arrives it is well to add a compound reducer. This reducer is usually a lower melting point compound having otherwise exactly the same characteristics as the original and mixing perfectly with it. Once the storage tank has been filled with compound it is generally unnecessary to add anything except reducer to replace that which is used in the coils.

The type of apparatus needed in the average shop for the proper application of insulating varnishes and compounds has been outlined briefly together with a description of the general methods to be followed. Whatever method is chosen for applying the varnish, be sure that the equipment is kept clean. Dirty equipment ruins insulation quite as quickly as does a faulty application. Wash your brushes or air spray as soon as you are through using them. Clean the varnish tank and strain the varnish at regular intervals. Remove the accumulation of dried varnish from the bottom of the oven. As in other lines of work, dirt breeds trouble. Keep your varnishing room and apparatus clean.

Goodyear Tire and Rubber Company

(Continued from page 163)

the world. The wholesale value alone of all the many rubber products manufactured in 1923 was upward of one billion dollars. In addition, the industry employs at the present time approximately 200,000 people in 170 manufacturing plants.

After the crude rubber is received it must be washed and worked up several times under heavy rolls to get it into usable form. In one of these rolling or milling processes, the crude rubber is mixed with various compounds, such as sulphur, litharge, coloring matter and other materials. In the manufacture of rubber goods in which cotton cloth is used, the cloth is impregnated with the rubber compound, or "frictioned." These coats are worked together under pressure and vulcanized under heat and pressure, which gives the goods their accustomed appearance. This treatment also sets the frictioned coat and gives the rubber the life and qualities which are required of it.

Automobile tires, one of the most prominent rubber products, are now largely made by automatic machines instead of by hand as was the former practice. This has resulted in the production of a better tire, because a machine can lay the friction-coated fabric or cord much more smoothly and evenly and draw it to the proper tension much better

than can be done by hand. One of the big problems of the industry is the seasonal demand for one of the most important products—automobile tires. To get steady production the year around requires large investments in finished materials.

Lineshafting and Hangers

(Continued from page 182)

the shaft, which would in this way cause extra friction in the bearings and an uneven or vibrating drive. If the belt is too tight any bend is pulled straight with every revolution; this results in a heavy power loss. It is not at all uncommon to find shafts which are bent enough so that it may be noticed by the eye as the lineshaft is in slow operation during the starting or stopping period.

Post hangers are used commonly to fasten shafting to posts or walls. These are made rigid and with two- or four-point adjustments. Where it is necessary to get the extension, as is necessary on a wall to permit the use of pulleys, extension arms are used. Rigid post hangers or boxes give but little opportunity for adjustment. Where adjustment and realignment are so difficult there is more excuse for neglecting misalignment. Post hangers are not used as much today as formerly due to the changes in modern building construction. With steel frame or trussed buildings the hangers are mounted on I-beams attached in turn to the steel trusses. Modern concrete buildings set special anchorages in the concrete ceiling to support shafting or other loads.

Pillow blocks are more commonly used on large shafts or in severe work. Here the cap of the bearing is usually held down with four cap screws and is much more rigid than in a four-point, adjustable shaft hanger where the bearing is held simply by the ends of four bolts. Sometimes on heavy-duty shafts pillow blocks are used on brackets as post hangers. Where the service is severe, and generally on shafting larger than 4 15/16 in., special sling hangers with pillow blocks on the wedge adjusting base plates are used to suspend shaftings. Heavy floor stands with adjustable pillow blocks are used in similar floor service. Whenever possible pillow blocks are mounted on concrete foundations when used for heavy service.

Pressed steel shaft hangers are being used quite extensively in ordinary industrial lineshaft applications. They are not generally used in heavy power service or in the larger sizes. Practically all are made with four-point adjustment.

A later article will take up a discussion of the various types of bearings used in lineshaft operation.

EDITOR'S NOTE: Special acknowledgment is made to the following companies for assistance in furnishing information, data and illustrations for this and the other articles which appear on this subject: Allis-Chalmers Mfg. Co., Milwaukee, Wis.; American Pulley Co., Philadelphia, Pa.; Bond Foundry & Machine Co., Manheim, Pa.; H. W. Caldwell & Son Co., Chicago, Ill.; W. E. Caldwell Co., Louisville, Ky.; Chicago Pulley & Shafting Co., Chicago, Ill.; Dodge Manufacturing Co., Mishawaka, Ind.; The Fafnir Bearing Co., New Britain, Conn.; Falls Clutch & Machinery Co., Cuyahoga Falls, Ohio; Gund Manufacturing Co., La Crosse, Wis., The Hill Clutch and Machine Co., Cleveland, Ohio; Hyatt Roller Bearing Co., Newark, N. J.; W. A. Jones Foundry & Machine Co., Chicago, Ill.; Link-Belt Co., Chicago, Ill.; Medart Co., St. Louis, Mo.; Midwest Steel & Supply Co., Inc., New York, N. Y.; Royersford Foundry & Machine Co., Philadelphia, Pa., Standard Pressed Steel Co., Jenkinstown, Pa.; The Skayef Ball Bearing Co., New York, N. Y.; The Transmission Ball Bearing Co., Buffalo, N. Y.; Weller Manufacturing Co., Chicago, Ill.; T. B. Wood's Sons Co., Chambersburg, Pa.

Frequency Changes in A. C. Windings

(Continued from page 193)

60-cycle winding, the original 25-cycle turns and wire size could be used. The only changes required would be in the coil pitch. In this case all new coils would have to be made up, as it is hardly ever possible to spring coils back the amount required in this change.

In any change the final calculations can vary at least 10 per cent higher or lower from the actual required amounts without any serious results in the operation of the changed windings.

When the use of these tables is thoroughly understood they will save considerable time and worry when it is desired to make any of the changes that have been described.

Changes in Rotors.—The statements thus far in this article cover the stator winding, but when changing the frequency, the rotor is also affected. If the rotor is of the squirrel-cage type, the resistance of the end rings will have to be altered. When the frequency is raised the resistance of both end rings must be increased. If the starting and full-load torques are to remain the same, on a 25 to 60 cycle change, the cross section of each end ring should be reduced one-half. If this is not done, the motor will pull an excessive current while starting and will also take a higher full-load current.

Therefore, when increasing the frequency, increase the resistance of the rotor end rings by decreasing the cross section of each ring according to the following proportional relation: A is to B as D is to C, from which the following formula is derived: $A \div B$ equals $D \div C$ or $B = AC \div D$, where A equals the area in square inches of each end ring at the old frequency, B the required area at the new frequency, C the old number of cycles and D the new number of cycles.

With a small cycle change, such as 40 to 60, 25 to 40, etc., the rotor can be put in a lathe and a cut taken off each end ring and with a 25 to 60 cycle change reducing the area of each ring one-half will be sufficient. When reducing the frequency, say, from 60 to 25 cycles, the resistance of the rotor end rings must be decreased, or the cross sectional area in square inches increased as indicated by the above formula, the letters having the same meaning. With a small frequency change such as 60 to 40, 40 to 25, etc., brazing the rotor bars to each end ring will decrease the resistance a sufficient amount.

The above changes are important and should be made regardless of any change made in the number of poles in the stator winding. The above statements are based on the fact that the resistance of the rotor end-rings on a 25-cycle motor is lower than that of the rings on a corresponding 60-cycle motor; conversely a 60-cycle motor will have higher resistance rings than those of a corresponding 25-cycle motor.

When the rotor is of the slip-ring type, and a change in the number of poles is made in the stator winding, a corresponding change must also be made in the rotor winding. That is, the rotor winding must be considered in the same light as the stator winding and the coil pitch checked. Then if a change is required, vary the turns per coil and size of wire according to the tables governing the stator change.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Midwest Steel and Supply Company, Inc., 28 West Forty-Fourth Street, New York, N. Y.—The 54-page architects' and engineers' data book on "Midwest Steel Sections" shows numerous methods and types of anchorage for erecting and supporting overhead shafting layouts, piping, cables, machinery, monorails, car tracks and various other equipment, either overhead, on the wall or the floor. Particular attention is given to types of anchorage and methods of installations in concrete buildings especially toward making provision for such anchorage in the construction of the building.

National Electric Manufacturing Company, Inc., 651 Chatfield-Woods Building, Pittsburgh, Pa.—Folders describe the "Syntron" electric hammer and illustrate its use for drilling or chipping. This is of about the size and appearance of an electric drill and will strike 60 hammer blows a second. The hammer head is driven back and forth between two coil magnets. This can be used for drilling or chipping and is portable so that it can be carried to any part of the plant. It is especially applicable for miscellaneous drilling in concrete such as is necessary for erecting machinery or for other miscellaneous maintenance and erection work.

U. S. Galvanizing and Plating Equipment Corporation, 32 Stockton Street, Brooklyn, N. Y.—A folder describes the U. S. moving electrode plating apparatus for plating with nickel, brass, copper, tin, silver, gold or zinc. This not only gives a description of the equipment and the advantages claimed for it, but also indicates the variety of work done.

Detroit Torch and Manufacturing Company, Detroit, Mich.—A folder illustrates and describes the various Detroit portable torches and fire pots.

Crown Die and Tool Company, 555 West Monroe Street, Chicago, Ill. —A 16-page catalog covers Crown pipe stocks, dies, cutters, reamers, portable pipe benches, and portable and bench vises. Diagonally serrated pipe-cutter wheels are claimed to be easy cutting and have a long life. These are made to fit any standard size of pipe cutters.

Warren Manufacturing Company, Natick, Mass.—A folder describes the Acme portable lamp and floor stand which has an adjustable arm so that it can cover any point within an 8-ft. circle and reach to a height of 7 ft.

Electric Tester Manufacturing and Sales Corporation, East Sixth and Stark Streets, Portland, Ore.—A folder describes the Universal fuse and circuit tester for testing alternating- or direct-current circuits of 110 to 600 volts. This tester is claimed to be amateur-proof and is compact, as it weighs only 8 ounces. The lamp is enclosed so that there is no danger of glass flying in case of breakage.

Weston Electrical Instrument Company, 4 Weston Avenue, Newark, N. J.—A 24-page booklet entitled "Electrical Savings in Industry" shows how Weston electrical measuring instruments may be used to obtain industrial economies. The interesting part of this booklet is that it shows actual economies made and how they were located. Some of the economies were in power distribution; others in the use of motors, in proper arrangement of motors, in a study of new installation, in investigations into equipment reliability and into the use of light, and in making a power survey.

Terkelsen Machine Company, 346 A Street, Boston, Mass.—A folder describes the Terkelsen machine for wrapping coils with a continuous protective strip.

The Ransome and Randolph Company, Industrial Division, Post Office Box 905, Toledo, Ohio.—A folder describes the special mica milling cutters and undercutter.

Wilboken Manufacturing Company, Milwaukee, Wis.—Catalog 23 gives the line of Wilboken electric pressure switches for use in controlling the operation of air compressors, pressure release valves with wiring diagrams, or switches to be used in connection with pumps where the equipment is cut in or cut out by floats or pressures, and other types of control switches.

The Imperial Brass Manufacturing Company, 1200 West Harrison Street, Chicago, Ill.—Folder 177 B covers the Imperial welding and cutting equipment which uses the oxyacetylene process. This includes also acetylene generators.

Trico Fuse Manufacturing Company, Milwaukee, Wis.—A folder entitled "When Buying a Fuse Look at the Inside" describes the construction and other special features of the Trico renewable cartridge fuse which is powder filled.

Whiting Corporation, Harvey, Ill.—Two recent folders entitled, "Bucket-Handling Cranes" and "Whiting Power House Cranes," illustrate and describe this equipment in use in the two fields indicated by the titles.

William W. Nugent and Company, Inc., 410-412 North Hermitage Avenue, Chicago, Ill.—Bulletin 6 describes the Nugent shaft oiler, a special oil can which enables the shop man to oil from the floor. This eliminates the necessity of using ladders for such work, and also eliminates the resultant accident hazard.

Chas. A. Schieren Company, 30-38 Ferry Street, New York, N. Y.—A series of bulletins entitled "Quality Facts About Belting" in looseleaf form will be distributed each month. Those requesting to be placed on the mailing list for this series will receive a binder for filing bulletins as issued each month. The first of the series on "The Buying Guide" discusses: The economy of good belting, its relation to production, the buying problem, specifications—their true values, and the real bases for selection.

Morris Electric Products Company, 101 Fourth Street, Peoria, Ill.—A recent folder describes the Havens universal lamp. This is a portable unit provided with five or twenty feet of extension cord and is provided with a wire guard and rotating reflector on a flexible gooseneck attached to a special grip clamp so that this portable lamp can be clamped on the work and the light easily directed over a wide range even in close quarters. This lamp combines portability and control of the direction of light close to the work in a small unit that can be carried in an electrician's or maintenance man's trouble outfit.

The Brown Hoisting Machinery Company, Cleveland, Ohio—Booklet 10 entitled "Man-Power Multiplied" describes the Brownhoist No. 2, locomotive cranes and shows how they reduce handling costs in eleven different industries. These cranes are mounted on either "creeper" trucks or on four- or eight-wheel railroad trucks and may be used with a bucket, magnet or with a special gripping device for handling miscellaneous material.

Efficiency Refillable Plug Company, 43 North Market Street, Palestine, Ohio—A folder describes a new refillable plug fuse which is made in capacities of 6, 10, 15, 20 and 30 amp. and 125 volts. Other literature describes the types of cartridge fuses manufactured by this company.

The F. V. Edwards Company, Noblesville, Ind.—Catalog C describes the line of "Never-Slip" friction clutches and couplings. These embody a special V-clamping device.

T. J. Tagliabue Manufacturing Company, 18-88 Thirty-third Street, Brooklyn, N. Y.—Catalog 904 covers the entire TAG line of industrial thermometers, automatic controllers, recording and dial indicating thermometers, vacuum gages, gas analysis recorders, oil testing instruments, hydrometers, laboratory thermometers and other products.

Condit Electrical Manufacturing Company, South Boston, Mass.—Bulletin No. 429-3 describes the Condit manhole oil switches, type M-5 and M-6, of a maximum rating of 300 amp. and 4,500 volts. These single-throw, two-, three- or four-pole switches are provided with a detachable supporting bracket and oil well to facilitate the treatment and testing of oil.

Delaware Hard Fibre Company, Wilmington, Del.—A folder describes "Egyptian" fibre, gives its characteristics, both physical and electrical, stock sizes, and suggestions on methods of working it.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

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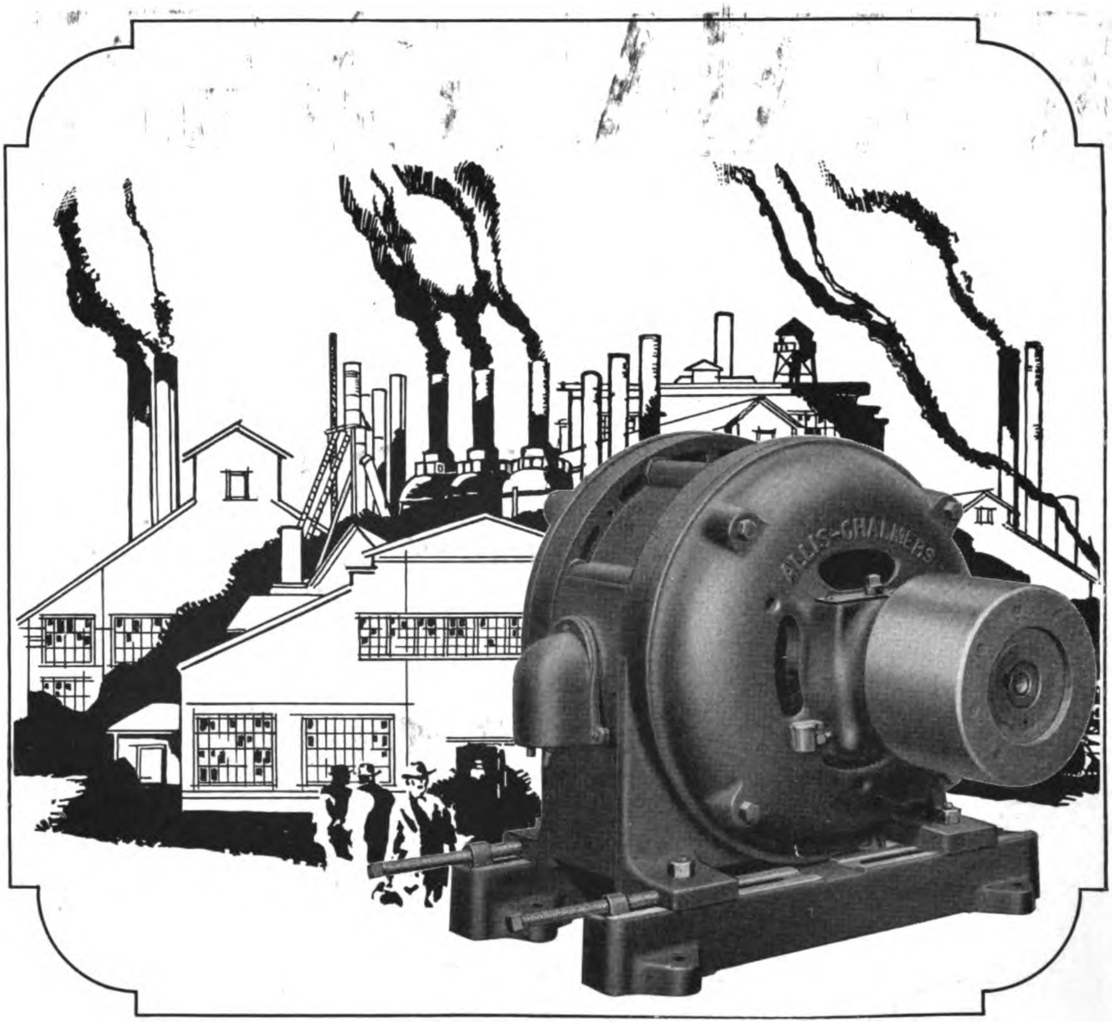

The Type "AR" Has a Broad Range of Industrial Usefulness

Allis-Chalmers Type "AR" Motors are of special interest to Plant Executives and Maintenance Men because of their all-steel construction, and the simplicity which results from unit features of design. For example, the stator end frames and feet are cast as a unit from electric steel. This insures great rigidity and eliminates breakage.

Intelligently selected for specific needs the "AR" has tremendous adaptability. It is capable of handling the stiffest assignment without faltering day in and day out for long periods. It is built for hard service and trying conditions and it does the job wherever put. Built in sizes from ¾ H. P. to 200 H. P. for all the standard voltages.

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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 82 Chicago, May, 1924 *Number 5*

Your Ideas Are Worth Money

But Like Ore in the Ground They Must Be Dug Up and Put Into Such Form That They Can Be Practically Applied

WE INTRODUCE to our readers through the accompanying photograph Mr. A. L. Carter, general repairman at the Westport plant of the Consolidated Gas, Electric Light and Power Company of Baltimore, Md. Mr. Carter is the winner of a $100 award for suggesting the use of Dot high-pressure grease guns in place of grease cups on ash conveyors, ash cars, stokers and coal equipment. He won the award because he proved that the idea would save the company more than $1,200 per year in preventing burning out of bearings, broken grease cups and removals of bearing caps to clean the grease grooves. He showed how the grease gun can be used to force out the small amounts of dirt that work into the grease groove and that the gun is no more expensive than the ordinary grease cup.

The system of awards set up by the company by which Mr. Carter is employed was inaugurated May 1, 1922. Since then $3,000 have been appropriated every twelve months to be distributed in monthly prizes of $100, $75 and $50 for the best operating suggestions that would produce a saving of at least $100 per month. In the statement outlining the basis of the awards, Herbert A. Wagner, president of the company, said in part:

"We know that we can do many things in a better way, and we look for and welcome suggestions from the men on the firing line. It is the desire of the management to encourage everyone in the organization to develop his powers of observation and his mental capacity for constructive effort, with the assurance that successful efforts will bring reward and advancement. The proposed awards are intended to be a constant incentive for economic suggestions and are open to any employee of the Company."

Ideas, like ore in the ground, are of little use until they are dug up and converted into a practical form. Then they are worth money to someone. The suggestion that I want to make to readers of this page is to dig up the results of your experience and the methods you have used to improve operation or cure troubles and send a brief description of the scheme to me. If it meets the ideas of the editors as a good practical suggestion you will be paid at the best rates that item will command. Some of our readers who are already following this plan are now receiving monthly checks varying from $2 to $50 depending upon the value of

the suggestion or article that is sent in. From January 1, 1922, to January 1, 1924, just two years, 238 readers of INDUSTRIAL ENGINEER contributed suggestions and articles.

Here, then, is a way that you can cash in on your ideas and besides join our family of men who are getting down in black and white a record of the worth-while things they are doing. Let's get acquainted and show, as Mr. Wagner has said, that the firing line is chock-full of suggestions for better ways of doing things.

Practical Pete

A Glimpse Into the

Works of Eastman Kodak Company

One-twelfth of the silver bullion produced in the United States is utilized in sensitizing films. In addition, production of sensitized paper, cameras, lens, and other photographic supplies offers widely diversified manufacturing problems.

ROUGHLY, the work of the Eastman Kodak Company, Rochester, N. Y., may be divided into two general subdivisions: The production of kodaks and cameras, and, of the film and printing paper to use with them. The first calls for a variety of manufacturing and assembly processes using chiefly aluminum, brass, steel, leather and wood. The manufacture of film and sensitized paper is a chemical process with a high fire hazard. As the quality of the product must be assured, many of the raw chemicals used are also produced.

A refrigeration plant with a total daily capacity of 4,350 tons—sufficient for a city of 200,000 people—and a private water supply system of twelve million gallons daily capacity, connected directly with Lake Ontario, six miles away, further suggest the scale of manufacture of this great photographic industry.

Power and light for Kodak Park are furnished by three turbine- and three engine-driven electric generators with a total capacity of 7,000 kw., or nearly 10,000 hp. Another 4,000 hp. is furnished by the Rochester Gas & Electric Corp. Approximately 4,300 motors are required to operate the machinery in the buildings and 40,000 electric lights are required to light them. Steam is supplied from two power houses, which are approximately a mile apart and use about 500 tons of coal a day. High-pressure steam is carried this distance through an especially-designed 12-in. pipe line.

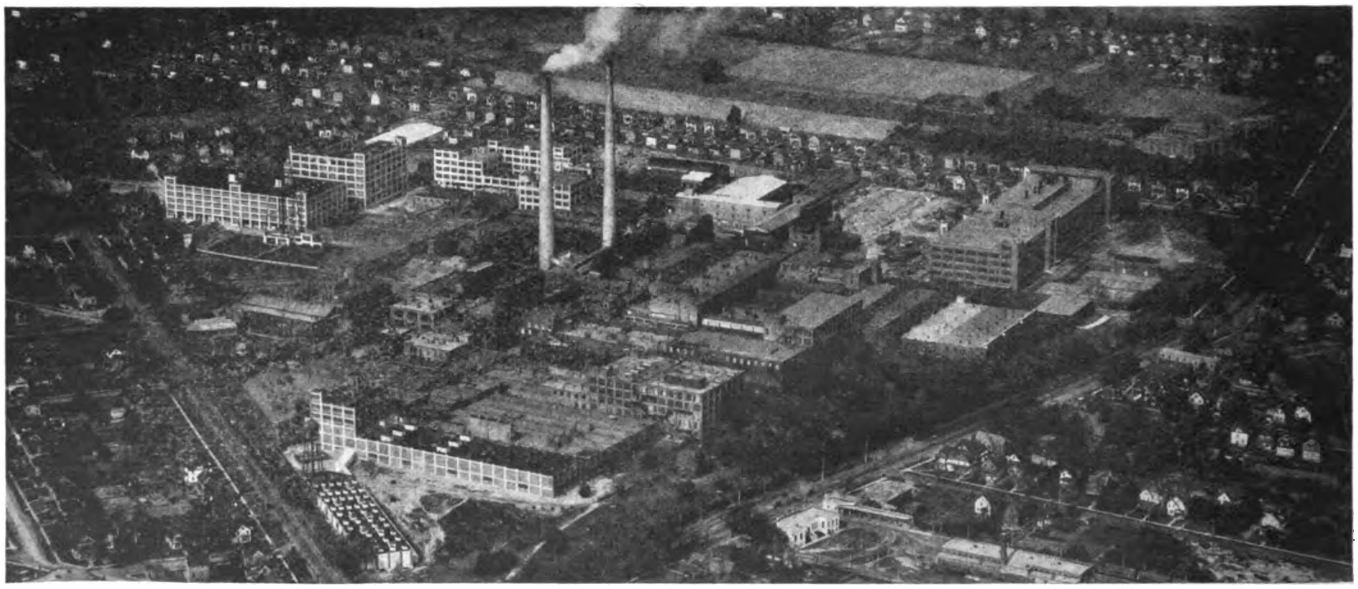
Plant and offices of the Eastman Company in 1890.

This factory building was used by the predecessor of the present Eastman Kodak Company a year or two after the kodak was invented. The first kodaks were loaded at the factory with film for 100 pictures; after making the exposures the amateur returned all to the Eastman Company to have the pictures developed and the kodak reloaded with a roll of paper film. In this way, the slogan, "You press the button, we do the rest," originated.

The first portrait made in America, in 1840, took six minutes to expose in strong sunlight, with the face of the subject thickly powdered to facilitate exposure. Today the same picture could be made in 1/1500 second.

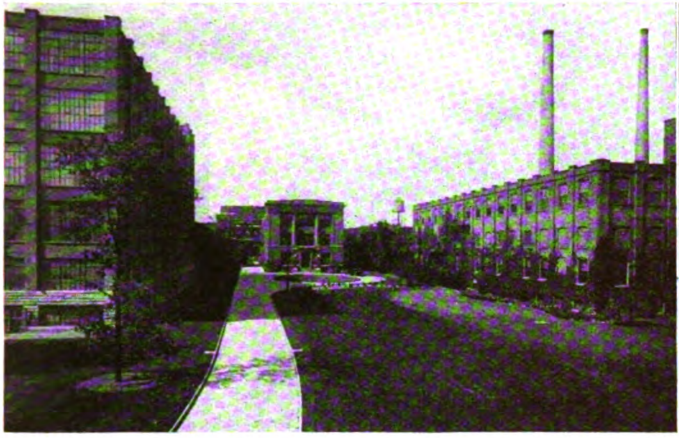
When George Eastman in 1878 became interested in amateur photography, the outdoor equipment consisted of a load of paraphernalia, which included a bulky view camera, heavy tripod, glass plates, dark tent for loading, unloading, sensitizing and developing the plates, nitrate bath and water carrier. The technical requirements were high also.

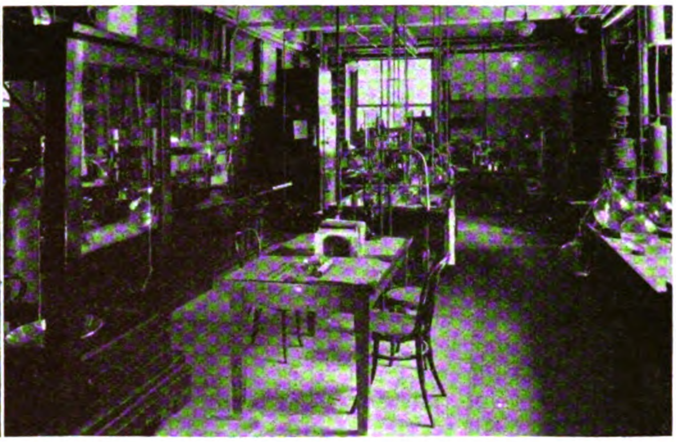
These were the collodion or "wet plate" days of the craft. Dry plates



Kodak Park Works is the largest of the four Rochester plants of the Eastman Kodak Company.

This plant covers about 230 acres and contains 119 buildings, with a floor space of over eighty acres. The principal products of this plant are: motion picture, kodak and portrait films, upwards of 150 brands of photographic paper, dry plates, chemicals, developers and other photographic equipment. In the preparation of these materials factories are maintained for the manufacture of raw paper, gelatin, acids, and many minor items. This plant has a capacity of about one hundred million feet of motion picture film each month, or approximately 225,000 miles per year. This plant maintains its own fire department with 150 trained men, and a large amount of equipment.

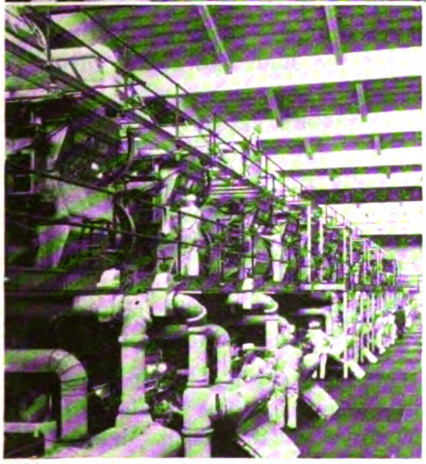




The entrance to Kodak Park and a room in the research laboratory.

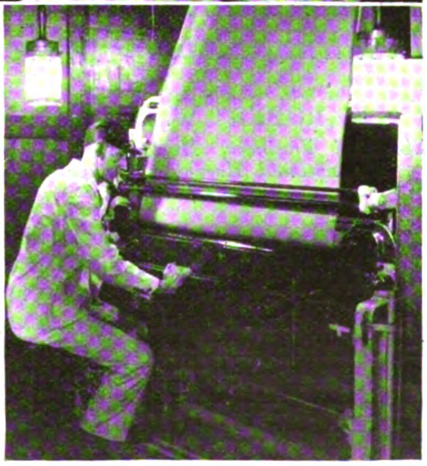
About eighteen of the 230 acres in Kodak Park are laid out with trees, shrubs and lawn. In addition, the workers have recreation and athletic fields with tennis courts, baseball diamonds, football grounds and a cinder track. A modern three-story building is erected solely for the use of the workers with separate dining halls for men and women, rest and smoking rooms, and a large assembly hall for dancing, musical programs, concerts, basketball and indoor baseball. The quality of the chemical materials used in photographic products is maintained by a staff of 120 chemists, physicists and photographic experts.

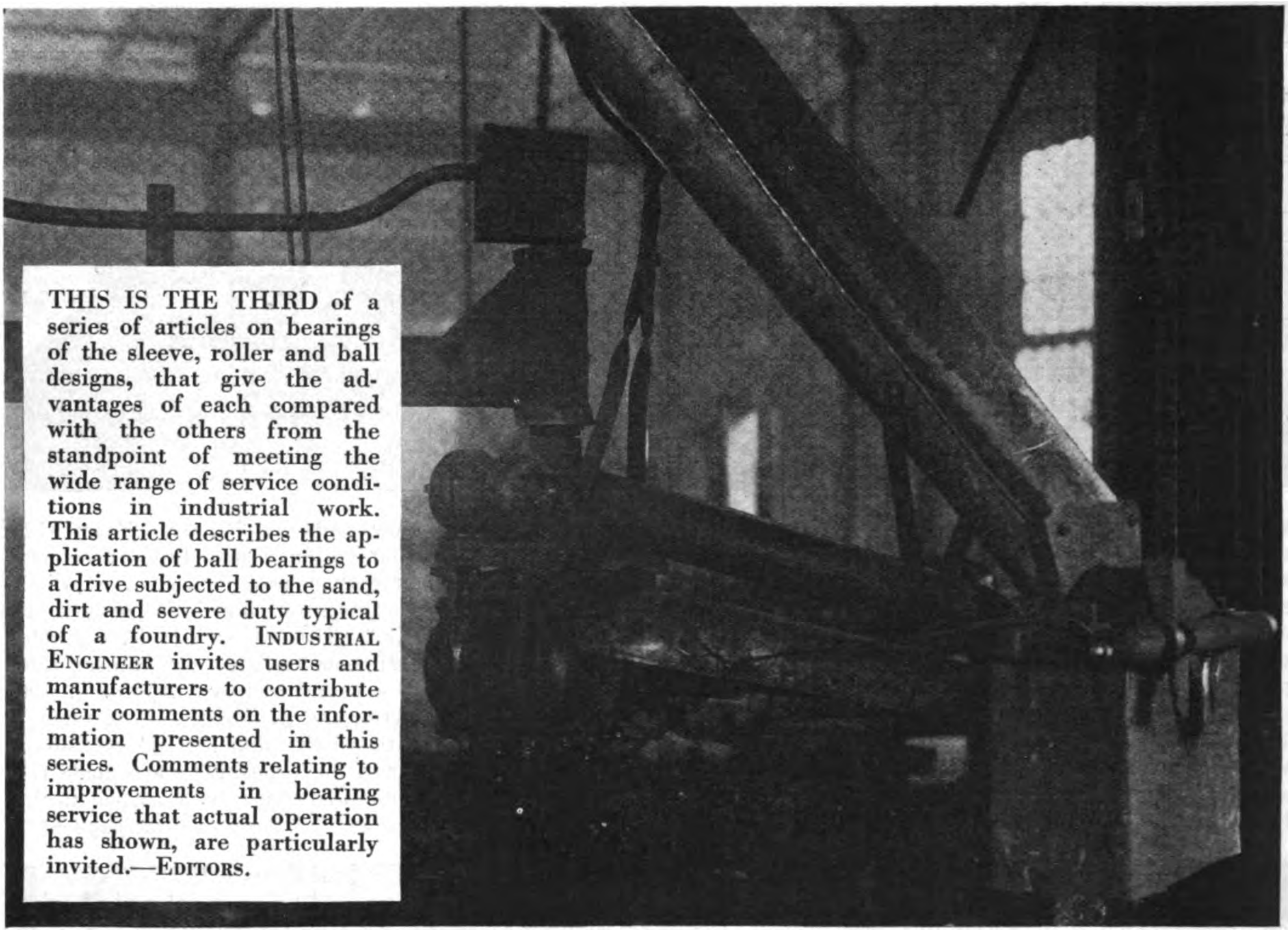
which Eastman brought out in 1880, scrapped a large portion of the load and made results less dependent on skill. But plates, whether wet or dry, are heavy and breakable and the inventor continued along the path of simplification with the roll-able-film idea always in mind. In 1885 a roll-film of coated paper, to which the sensitized emulsion was affixed, was realized and a roll holder adapted it to the ordinary view cameras in use. From this combination a new type of camera altogether was devised for which the inventor coined the name "kodak." This was a simple, portable, easily manipulated box camera that took round pictures $2\frac{1}{2}$ in. in diameter, and was loaded at the factory with rollable film for 100 exposures. When the exposures were made the kodak and film were returned to the factory *(Continued on page 258)*



Four steps in the manufacture of photographic film.

The base of film is a cellulose product made by nitrating cotton. After washing and drying, the cotton is treated with a mixture of nitric and sulphuric acids. The excess acid is removed in the centrifugal machines (upper left). This nitrated cotton is mixed with the solvents, of which alcohol is the principal ingredient, until it is a thick mixture. At the coating machine (left) it is made into sheets 2,000 ft. long and $3\frac{1}{2}$ ft. wide, which, when dry, become the familiar transparent thin film backing upon which is spread (right), the sensitive coating of salts of silver. The pure silver bullion is first dissolved in nitric acid to form silver nitrate (above at right), evaporated to crystals and later mixed with potassium bromide and gelatin, dissolved in hot water into an emulsion which is spread over the film (at right). The film is then slitted and wrapped on spools or cartridges.





THIS IS THE THIRD of a series of articles on bearings of the sleeve, roller and ball designs, that give the advantages of each compared with the others from the standpoint of meeting the wide range of service conditions in industrial work. This article describes the application of ball bearings to a drive subjected to the sand, dirt and severe duty typical of a foundry. INDUSTRIAL ENGINEER invites users and manufacturers to contribute their comments on the information presented in this series. Comments relating to improvements in bearing service that actual operation has shown, are particularly invited.—EDITORS.

How Bearing Troubles Were Corrected by

Changing Housings To Use Ball Bearings

And Frequent Inspections and Replacements of Former Bearing Sleeves, End Bells, Shafts and Resulting Repairs Were Prevented.

Dust-proof housings and ball bearings are used on this motor.

The motor drives a member which is approximately balanced when new but is rapidly worn by the action of the sand passing through it so that replacement of it is necessary once or twice per shift. Before replacement this member becomes tremendously out of balance and the vibration from it is transmitted to the bearings of the motor direct connected to it. Before ball bearings were used in this motor, the sleeve bearings averaged six-week's life but many failed to stand up six days. They failed by pounding loose in the end bells. The cylindrical object above the motor is the control switch.

By ROBERT W. DRAKE
Electrical Engineer, McCormick Works, International Harvester Company, Chicago, Ill.

OFTENTIMES something more than the application of ball or roller bearings is required to correct a troublesome bearing situation. This article describes the application of ball bearings to a heavy-duty drive subjected to an unbalanced load and to an atmosphere filled with sand, and relates the methods used to make a sand-tight bearing housing. The same methods could be used on any bearing subjected to excessive dirt or which must perform in an atmosphere filled with abrasive material such as cement, sand, coal or emery dust.

During the war, several molding machines of an entirely new type were installed at the plant with which I am connected. As producers of molds they were a great success, but the maintenance of the driving end was quite a problem. The machines were served by an overhead sand conveyor system. One 2-hp. motor fed the tempered sand to the machine, a 1-hp. motor riddled the sand and fed it through the molding machine, while a third motor of 3-hp. capacity operated the molding mechanism. The motors originally furnished with these machines were standard, constant-speed, induction motors of competitive grade.

DRIVE OPERATES UNDER UNUSUALLY SEVERE CONDITIONS

The operating conditions were unusually severe. The whole machine was subjected to a faint "drizzle" of falling sand. The 2-hp. motor operated a crank mechanism, which required a varying torque, ranging

from zero to approximately 175% of full load every two or three seconds. So heavy was the load that a standard motor would not start at the point of maximum torque and a motor with a high-resistance rotor was necessary. The 3-hp. motor was direct connected to a member revolving at 1200 r.p.m., which was approximately balanced when new, but was rapidly worn by the action of the molding sand which passed through it, so that replacement of the part constituting the wearing surface was necessary once or even twice per shift. Before replacement, this revolving member was tremendously out of balance due to wear. The consequent vibration was transmitted back to the direct-connected motor, giving a service comparable to that experienced with a steel pinion of coarse pitch and few teeth, which is operated with a very badly worn gear.

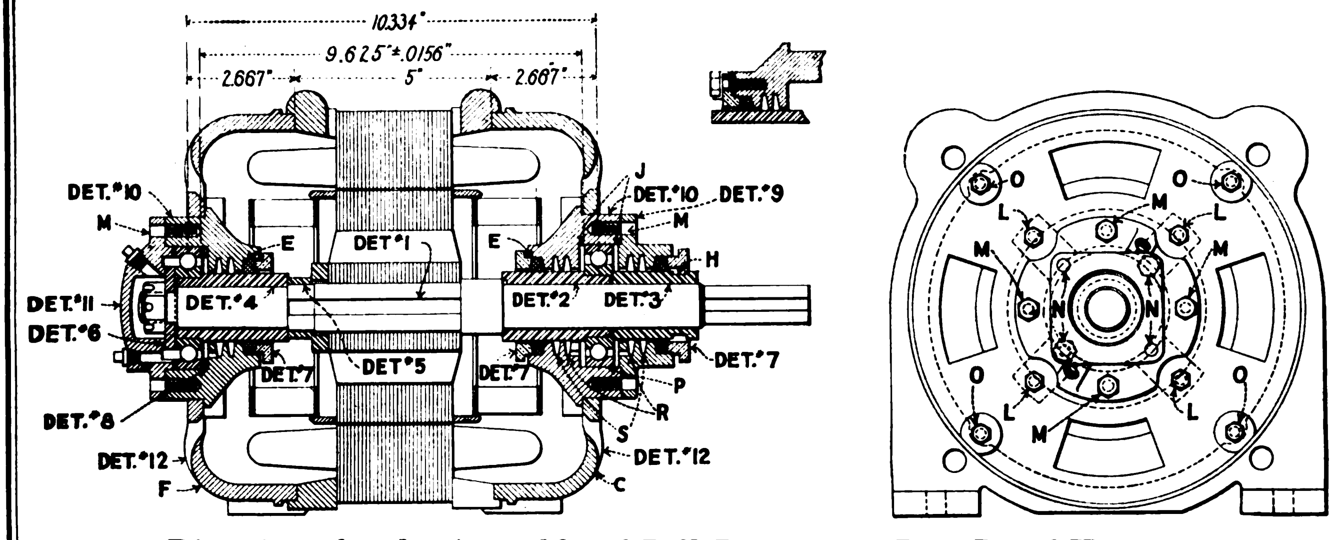
The motor bearings as furnished were die-cast sleeves. These sleeves averaged six-weeks' life but many failed to stand up six days and some lasted scarcely as many hours. They commonly failed by pounding loose in the heads, or end bells, rather than by wear. The end bells also wore rapidly as soon as the bearings became loose. The average life of end bells was less than one year. Shafts wore out in a few months.

Stuffing boxes on this ball-bearing housing make it dirt and grit tight. The bearing housing in which is placed the ball bearing, is split into two parts which are held together by the bolts, *M*. This housing is fastened to the end bell or head, Det. 12, by the bolts, *L*. The end bell is fastened to the stator frame by the bolts, *O*. The bolts, *N*, tighten the gland, Det. 7, in the stuffing box. When the rotors are changed the bearing housing is not opened but is changed with the rotor. When changing rotors, the end bells are removed by taking out the bolts, *O* and *L*. The rotor complete with bearings enclosed in their housings is then removed as a unit. Any repairs that may be required for the bearings, are made in the electrical repair shop.

The time of one competent motor inspector was required for thirteen machines (thirty-nine motors) and he worked ten or fifteen hours per week overtime (frequently with one or two assistants) replacing bearings, changing motors and rotors and carrying out other repairs which could not be made while the machines were in operation. How much time was spent by machinists making parts, pressing in new shafts and doing other repair work for these motors, I do not remember.

Ball Bearings Selected for the Application

Clearly here was an application which called for a super-motor, a design having ruggedness as far superior to the ordinary, constant-speed a.c. motor, as the best mill-type d.c. motor is superior to the ordinary type of d.c. crane motor. If a reliable motor could be obtained, the saving in repairs would



Directions for the Assembly of Ball Bearings in Dust-Proof Housing

I. Assembly of Rotor—to Be Done by Toolroom.

A. Assemble Det. 2, 4 and 5 on shaft. Assembly dimensions must be within 1/64".

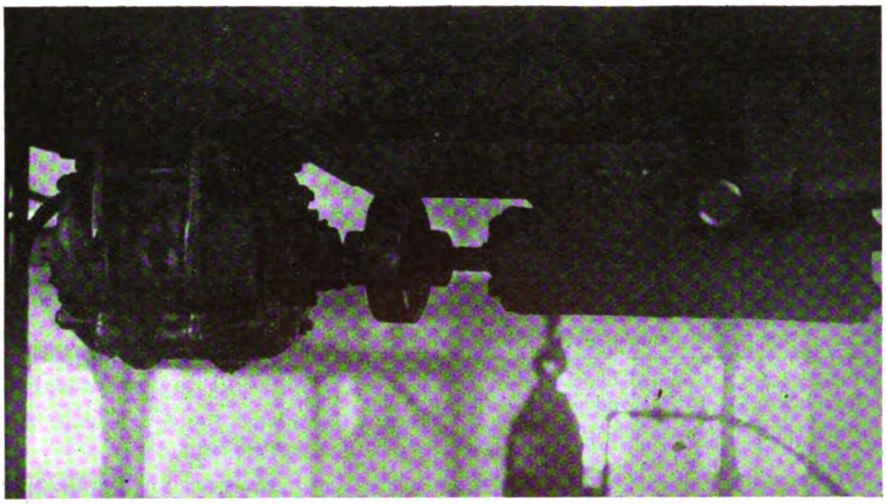
II. Assembly of Bearings—to Be Done in Electrical Shop.

A. Assembly of Coupling-End Bearing.

1. Check all dimensions as per drawing.
2. Assemble stuffing gland, tighten gland bolts with fingers and lock with washers, as shown in small sketch in upper center of drawing. Hole in washer must be neat fit for bolt. Soak felt in cylinder oil before assembly.
3. Assemble inside half of bearing housing, Det. 7-10. Care being taken that felt packing is in place.
   Heat bearing to 170 degrees F. in an oil bath. Slip the bearing into place and strike lightly with a pipe slightly larger than the shaft.
4. Press short bushing, Det. 3, into place. Pack bearing with *vaseline* then put outside stuffing box, Det. 9, and gland, Det. 7, into place.

B. Assembly of Front-End Bearing.

1. Proceed as in 2 above.
2. Put filler washer into place, Det. 8. Then slip bearing into place cold.
3. Put washer, Det. 6, into place and tighten nut on shaft firmly. Pack with vaseline as above.
4. Put head, *C*, on coupling end of motor and put cap screws in place.
5. Slip rotor and bearings assembled, into place from front end of motor.
6. Put motor head, *F*, on front end and tighten cap screws.
7. Put on front end cap and test rotor for end play. This should be 1/16" ± 1/64". If it is more or less than this, the motor must be run with the front end cap removed, and careful measurements taken to see whether the filler ring, Det. 8, is the proper thickness and whether a washer is needed under the cap or something must be turned off the end cap. The rotor should float without rubbing on the filler ring.
8. When end play of rotor is correct, drill shaft nut and shaft for a 1/4-in. cotter pin. The eye of the pin must be hammered down flat and the bent end cut off short to keep the pin from rubbing on cap.
9. Gage air gaps on each quarter of motor and rotate heads to bring largest gap at bottom of motor when installed in place.
10. When necessary to change bearings or rotor, take out cap screws that hold the stuffing box to the head on front end and coupling end of motor. Then take out cap screws that hold head, *F*, on front end of motor. The rotor and bearings can then be taken out the front end and new parts put in place.



This motor is subjected to a faint "drizzle" of falling sand from the sand conveyor overhead.

It operates a crank mechanism which requires a torque varying from zero to 175 per cent every two or three seconds. Due to the sand and the heavy load, bearing replacements were frequent until ball bearings enclosed in the dust-proof housing described in this article were used.

quickly repay any cost, reasonable or unreasonable. The saving in idle time and manufacturing delays would be greater still.

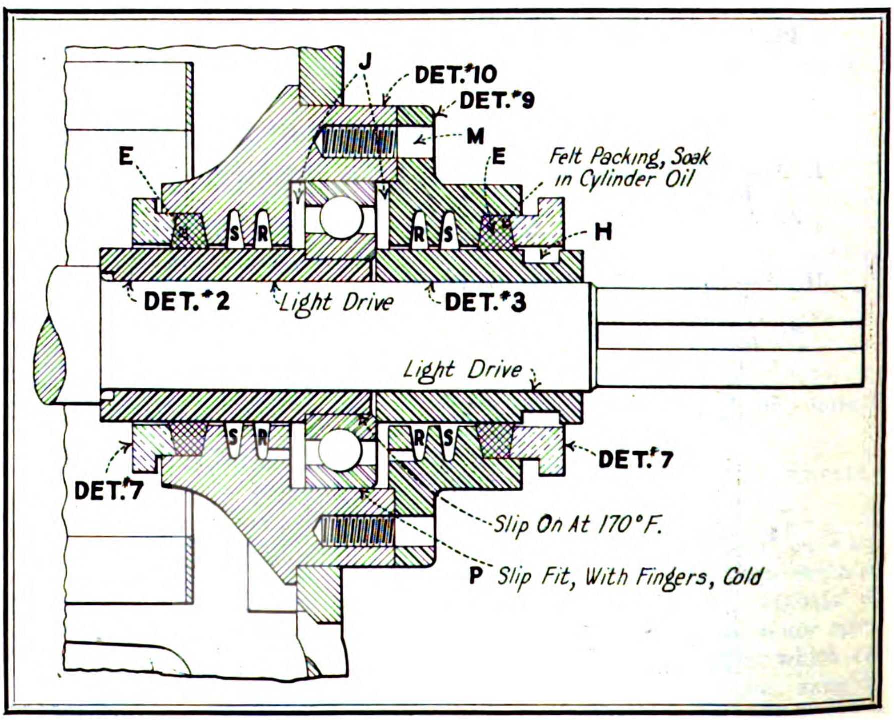
A year was spent in gathering data on repair costs, to convince the powers who hold the purse strings that a considerable expenditure was warranted; in various experiments with bronze bearings; in a vain effort to find a bearing material which would give a reasonable life; and finally in a canvass of available commercial motors in the hope that some make of squirrel-cage induction motor could be found which would give a reasonable degree of reliability on this application.

We finally decided that no type of sleeve bearing with special dust protection would give the degree of reliability which we sought. We turned to ball-bearing or roller-bearing motors as a last resort. Certain requirements of the service convinced us that no commercial make of ball- or roller-bearing motor then available would do, and we were forced to the conclusion that we must design the mechanical features of the required motor ourselves.

The nearest similar service of which we could learn was the d.-c. axle-driven, lighting generator used under Pullman cars. These generators must operate under the cars for several days at a time without attention or repairs. They are subjected to a veritable bombardment of cinders, dust and grit sucked up by high-speed trains. Maintenance of bearings and shafts is almost as much of a problem as in our application, except that hammering due to unbalance is not the rule. We learned that Mr. Ernest Wanamaker, Electrical Engineer, The Rock Island Lines, had attacked this problem by a design using oversize ball bearings, packed in grease and with special protection against the entry of dust. After several years of experimenting, he had evolved a design which was remarkably reliable. We turned to him for advice and designed an experimental motor based on his experience. It stood up admirably, but it was lacking in several particulars necessary for our service and it was also hard to dismantle and repair. We then evolved a design in the light of this experience which has proved very satisfactory. With twenty-six of these motors in service for an average of one year each, we have been called upon to make only one bearing repair.

Bearing housing for the coupling end of the motor.

Det. 2 is a renewable sleeve which is a light driving fit on the motor shaft. The inner race of the ball bearing fits over this sleeve and the outer race of the ball bearing slips inside of Det. 10 at *P*. Det. 10 is half of the bearing housing which is held to the other half, Det. 9, by bolts at *M*. Both ends of the housing are sealed at the shaft by means of stuffing boxes, of which *E* is the packing and Det. 7 are the glands.



FEATURES WHICH PREVENT DUST FROM ENTERING BEARING

I will describe the main points of the bearing and explain the reason for each and the results accomplished. We used the stators of the original competitive-grade motor, as we had experienced very little stator trouble, except that due to bearing failures and consequent rubbing of the rotor on the stator. As our machines were built to fit these stators, we realized that we must either replace complete motors whenever trouble occurred or evolve a design which would allow the replacement of rotors without opening up the parts enclosing the ball bearings, for the drizzle of sand would surely get into the ball-bearing chamber if this chamber were opened in the foundry. This was accomplished as shown in the illustration on page 217. The ball bearing is enclosed in a split housing, which is sealed tight at the shaft by means of stuffing boxes. This housing is bolted to the head of the motor. On page 218 is

shown a cross section of the bearing at the coupling end of the motor. Det. 9 and Det. 10 show the halves of the housing. Each half is equipped with a stuffing box and gland, Det. 7. Since it was thought that the felt packing at *E* in the stuffing box would cause rather rapid wear of the shaft, the renewable sleeves, Det. 2 and 3, were pressed on the shaft to provide for wear. The inner race of the ball bearing fits tight on the sleeve, Det. 2, and the outer race is a "sucking fit" inside of the half housing, Det. 10 at *P*. This allows the outer race to revolve slowly, thus distributing the wear on the inside of the race.

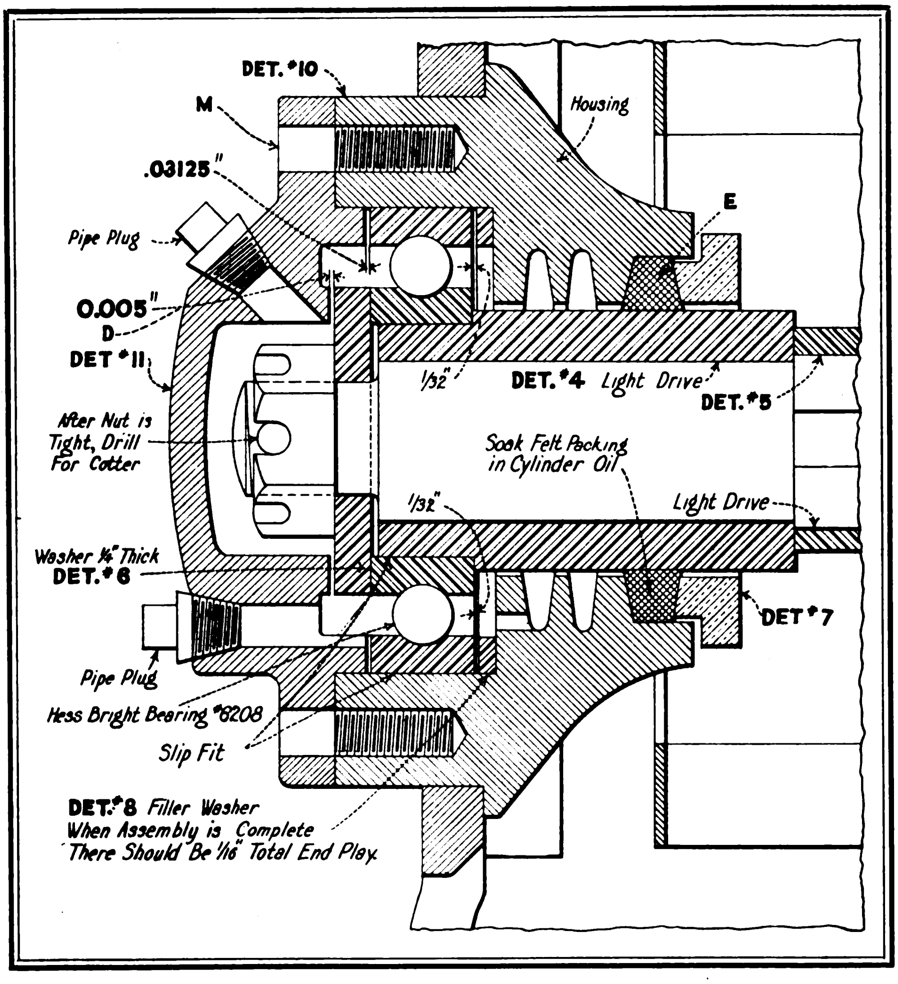
There are several features of particular interest concerning the stuffing boxes and the renewable sleeves. The sleeve, Det. 3, has a groove at *H* to facilitate the removal of the sleeve. The grooves, *R*, in the stuffing box are intended to catch the grease working out around the shaft and return it to the bearing through a hole at the bottom of the groove. The grooves, *S*, are intended to catch dirt that might work in through the packing.

The end bells or heads, *C*, and *F*, may be removed, after which the rotor, complete with ball bearings and with bearing-enclosing housing undisturbed, may be replaced. All parts are interchangeable and a complete spare rotor with ball bearings and enclosing housing may be substituted with the assurance that it will fit. The defective rotor assembly may be taken to a clean place in the shop and disassembled.

Bearings Will Take End Thrust from Driving on Coupling

The motor is connected to the driven machine by a coupling. This coupling must be tight or it will work loose and wear the shaft. This means drive the coupling and drive it hard. We wished to avoid the complication of an additional thrust bearing to take this sledging. The illustration on this page shows how it was accomplished. Det. 4 is a renewable sleeve which is a light driving fit on the shaft, the same as Det. 2 on the other bearing shown on page 218. The inner race fits over Det. 4 and the outer race fits into Det. 10, which is similar to the half housing used on the bearing on the coupling end. The inner race is clamped by means of the nut and washer on the motor shaft. End thrust is taken at *D* between the washer, Det. 6, and the bearing cap, Det. 11. There is commonly 0.005 in. clearance at *D*. The ball bearing will give 0.005 in. without injury. Thus the force of the blow is taken by the bearing cap, Det. 11.

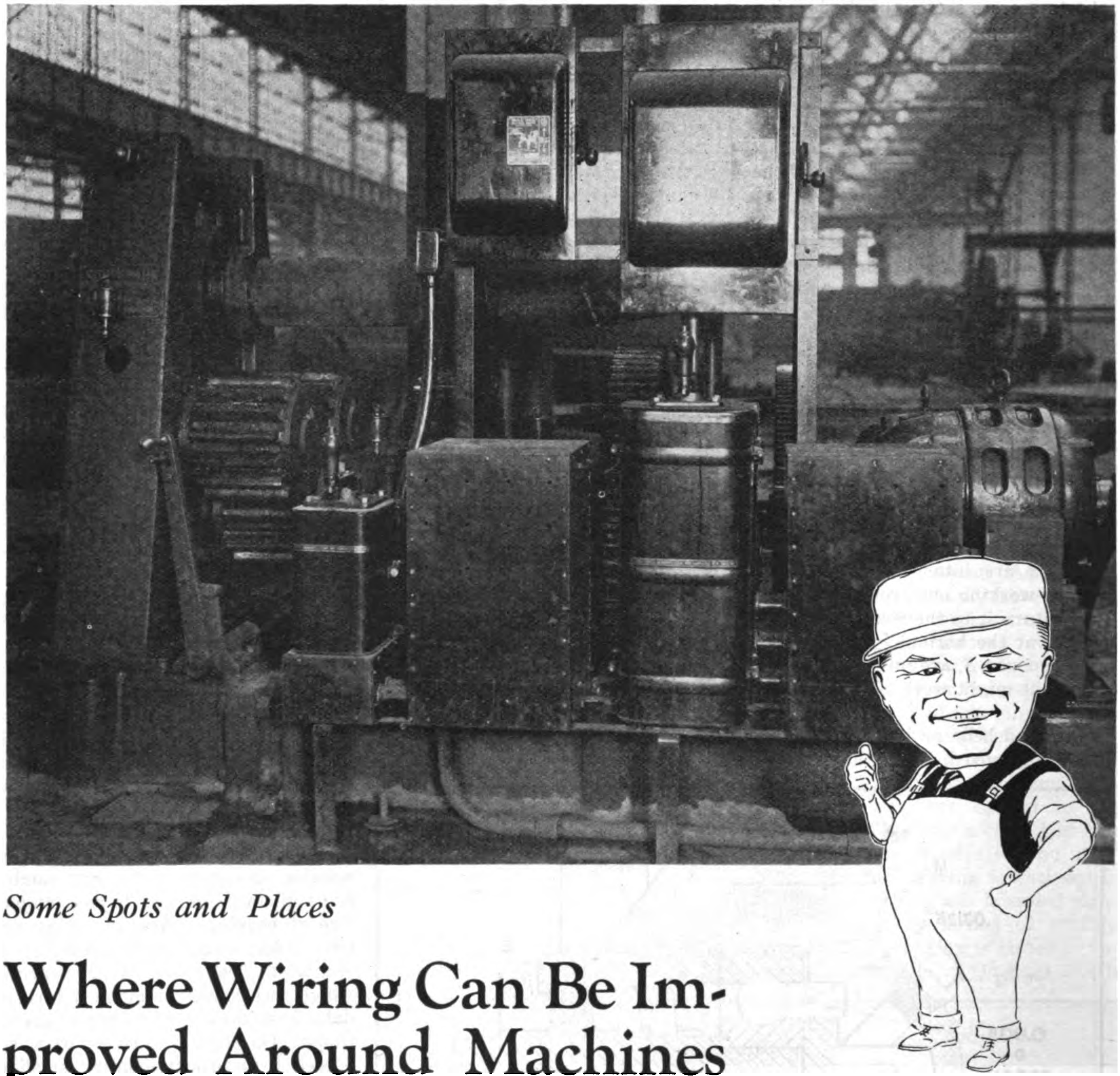
The front-end bearing is arranged to take the end thrust from driving on couplings or pinions.
Det. 4 is a renewable sleeve over which is slipped the inner race of the ball bearing. The outer race is a slip fit in the housing half, Det. 10. The inner race is clamped on the renewable sleeve, Det. 4, by means of the washer, Det. 6, and the nut screwed on the end of the shaft. The end thrust on the shaft is taken at *D*, between the washer, Det. 6, and the other half housing Det. 11, which is bolted to Det. 10. There is 0.005 in. clearance at *D*, between Det. 6 and Det. 11. The ball bearings will "give" axially 0.005 in. without injury, hence the end thrust caused by driving on a pinion or coupling will be transmitted from the shaft to the bearing housing.



The bearings are run in pure refined vaseline or petrolatum. We do not use oil, for the motors are ordinarily thickly covered with sand. We wish to remove the oil filling plugs as seldom as possible. Packed in vaseline they will run for a year. Several of these motors have been running for three years without a change of grease. A few have been examined but were found well greased. No grease will be given these bearings until the need for it has made itself evident.

Judging from Mr. Wanamaker's development work, one necessity for reliable operation under grit conditions in severe service is very ample size of bearings. We are using on our 3-hp., 1200-r.p.m. motor, a standard, heavy-duty type bearing which, according to manufacturer's data, is suitable for a motor of about 50 hp. On our 2-hp. design we were forced to a proportionately smaller size of bearing by space considerations. These bearings are far above the manufacturer's recommendations as to size. They have stood up admirably but they are not subject to such severe abuse as are those on the 3-hp. motors.

There is at present a widespread interest in ball-bearing motors for general service and special applications. It is hoped that this brief description may offer interesting suggestions and a basis for further improvement by others. About forty motors of this general type have been operated under exceedingly severe conditions on the previously described molding machines and on direct gear drives with metal pinions. The results have been beyond our hopes. *(Continued on page 257)*



Some Spots and Places

Where Wiring Can Be Improved Around Machines

With Do's and Don'ts That You May Know About Arranged to Save You Time When Breaking in New Men and Helping Them to Understand Why You May Be so Fussy About Doing a Good Job

Suggestions by

Practical Pete

This is a "regular" job. There are two wound-rotor induction motors driving this bending roll which is located in a boiler shop. Notice the box the electrician has built around the terminal leads of the motor. The two enclosures with small holes punched in the sides are steel boxes enclosing the resistors. Possibly it would have been better to use grille-work instead but, providing the resistors do not overheat in these enclosures, it will be found that the sheet metal gives more protection to the resistors than the grille-work would. To the left of each box are the drum controllers and above the drum controllers are the safety switches for each motor. The conduit work is very good—notice how the wireman has used elbows where he was not crowded for room beneath the resistors; and look at the nipples connecting the drum controllers with their respective resistor boxes. The conduit is not conspicuously located and is placed so that it is well protected. The condulets at the left-hand safety switch and at the motor terminal box give the job a neat appearance. Rear-cover condulets were used so that wires could be easily pulled.

I HAVE SEEN a lot of bum wiring and I have seen still more that was fairly good, but in the course of the last few years from my visits to many different kinds of plants I have come to realize just how good and just how badly a wiring job can be done. I have always maintained that a job of wiring can not be done too well. But it was not until one of my friends showed me his prize installation that I fully comprehended the dollars-and-cents value of a really good wiring job.

In one room of his factory in which power for twenty operators is furnished by one motor, $100 covered the cost of the drive installation, including foundation, conduit, wire, wiring supplies and labor. The wages of the twenty operators de-

pending on this single motor drive amount to $10 per hour. Any refinement or improvement in this installation that will prevent three twenty-minute shutdowns per year will, therefore, result in a saving of $10 worth of labor that would be otherwise lost. Twenty per cent is a fairly good return on an investment and a safe figure to use in determining how much money could be spent to prevent a one-hour shutdown per year on this motor. At 20 per cent, $50 will yield $10 a year. Consequently, an additional initial investment of $50 on this installation is justified if it saves only one hour of delay a year. Since the wiring and installation cost for this motor amounted to $100, an increase of 50 per cent of the actual wiring and installation cost would be justified if it saved the $10 per year in lost labor time. The point I am trying to get over is that it pays good dividends to install wiring and equipment in a substantial manner.

There are several important factors that determine the location and installation layout of wiring, conduit, motor and control equipment. These are:

(1) Safety
(2) Continuity of operation
(3) Convenience of operation
(4) Ease of construction
(5) Cost

Safety Is First Consideration of Any Installation

If the installation layout that is being considered is unsafe, or likely to cause an occasional accident, it should at once be discarded. Even a considerable increase in machine output or lower installation costs, are unprofitable and expensive if the installation is a hazard to life, or machines or increases fire risk.

What, then, is a safe installation? First and foremost all "live" parts should either be enclosed or guarded by screens or grille-work. This includes switches, starting boxes, control panels, field rheostats, resistors and other control equipment. The operator should be free to concentrate his entire attention on his job and should not be required to remember that this or that part is "hot" and he must not get too close to it nor touch it. The installation should be made so that it is impossible for the operator to touch a live part. Enclosed safety switches are now available at small cost that eliminate the dangers of open knife switches. Starting boxes and field rheostats are arranged with a cover over the buttons and an operating arm outside of the case. Resistors are provided with iron grille-work covers. Control panels can be covered with grille-work, or better yet, enclosed in a sheet-iron case.

One plant that I know of encloses all control panels in sheet-iron cabinets which are padlocked and only the electrical maintenance men have the key. This same key fits the padlock on the safety switches and also the lighting distribution cabinets, and any other boxes or enclosures to which only maintenance men should have access. In another plant, in which a great many control panels are used, the panels, resistors and distributing buses are located in a control room, to which only electrical maintenance men have access.

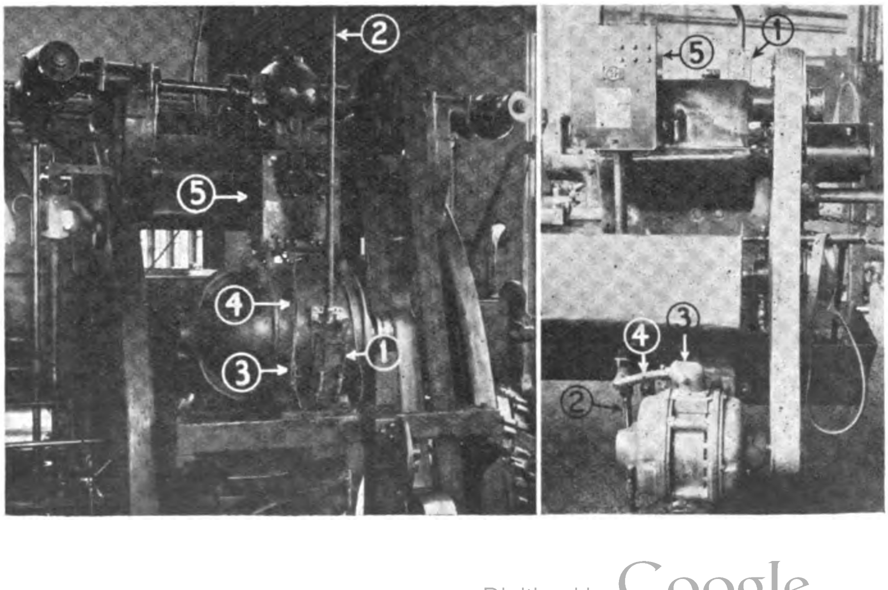
In this same plant since the motors may be at a distance from, or out of sight of, the control panel or master switch, a safety switch is mounted on the railing inclosing the motor. This safety switch disconnects the motor from the wires leading back to the control panel. Consequently, when motors are being changed or when repair work is being done on the motor or machine driven by the motor, the safety switch is opened and locked open by a padlock carried by the repairman. This prevents any danger of shock or the possibility of someone starting the drive.

It is hardly necessary to say that all moving parts should have some kind of enclosure or protection. Belts, gears, couplings, shaft ends and the like should either be enclosed or otherwise guarded.

Once in a while a young fellow gets the idea that his boss is an old fogey and particular far beyond any practical necessity. But after a few years of experience, when he gets in a boss's boots he forgets that at one time he did not know it all and sometimes bears down a little hard on his men when their work is not just up to the standard that he knows it might be.

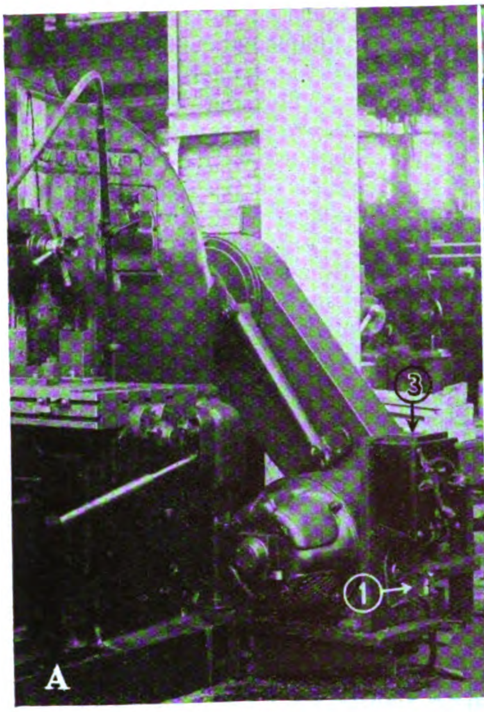
Because I used to be one of those young fellows and later was a boss, I have tried in this article to point out the things that make a wiring job good and give the reasons therefor. If you are a boss pass this article around among your men. If you are not yet a boss, but expect some day to be one and want more information on any of the points discussed, just drop me a line and I'll try to give you what you want.

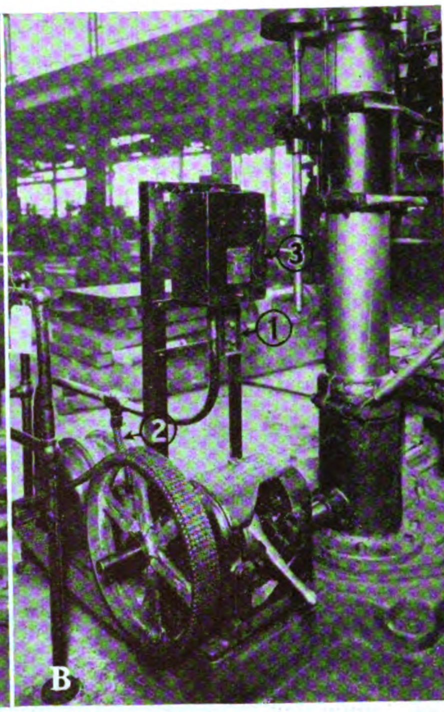
This article will be followed by another with plenty of pictures of good and bad wiring jobs, so that you can check up your own work and sort of make a mental examination of how good or bad it may be.

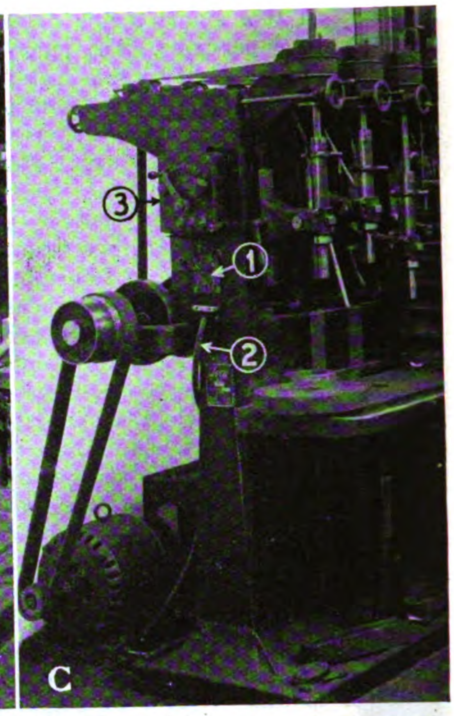


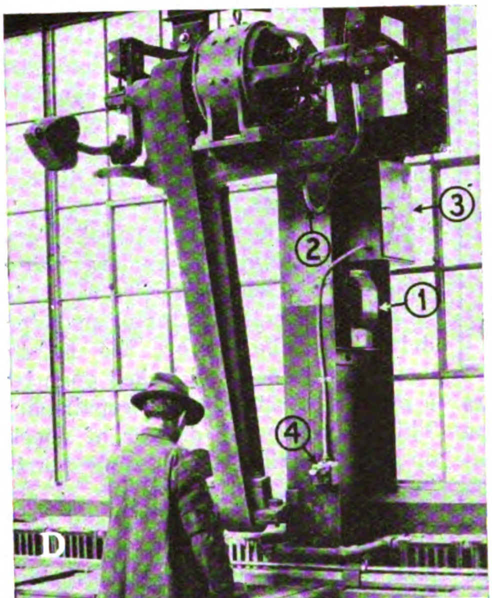
The installation shown at the left is not so bad, but you and I can see lots of ways that it could be improved.

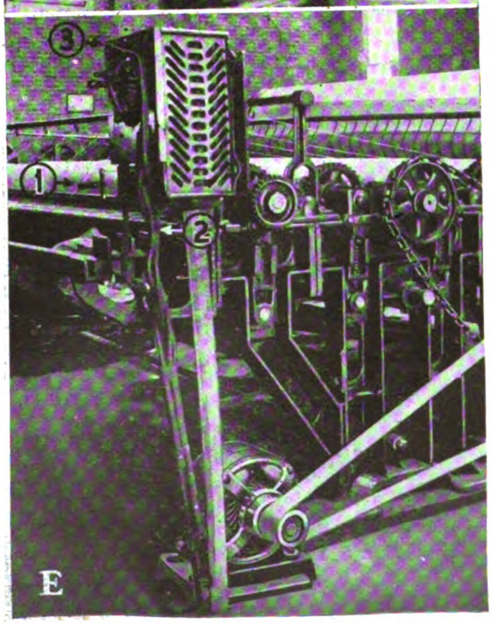
For instance, that open knife switch (1) is in a very poor location. The switch ought to be placed so that the operator could reach it from the other side of the machine when he stands at his work. And besides, it ought to be an enclosed switch. Contrast this with the conveniently located push button (1) in the right hand illustration. I don't like the conspicuously located, unprotected conduit (2) which runs up to the ceiling. Compare that with (2) in the right hand picture. What do you think of the comparison between the two installations at (3), (4) and (5)?











Do you like to see exposed knife switches near the floor, as at (1) in illustration (A)? I don't like to see them anywhere.

Compare (1) in *A* and in *C* with the push button starter shown at (1) in illustration *B*. Most of us prefer flexible and rigid conduit to the use of loom as shown at (2) in *C*. Contrast this with (2) in *B*. Don't you think that the inclosed-type starter (3) in *B* is much better than the exposed type (3) in *A* and *C*?

* * *

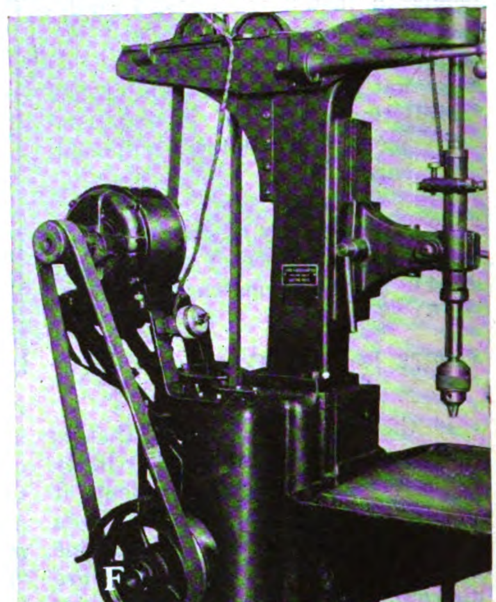
The installation shown in illustration (D) is one that I like to look at. Take a look at the safetw switch (1) and compare it with (1) shown in illustration (E).

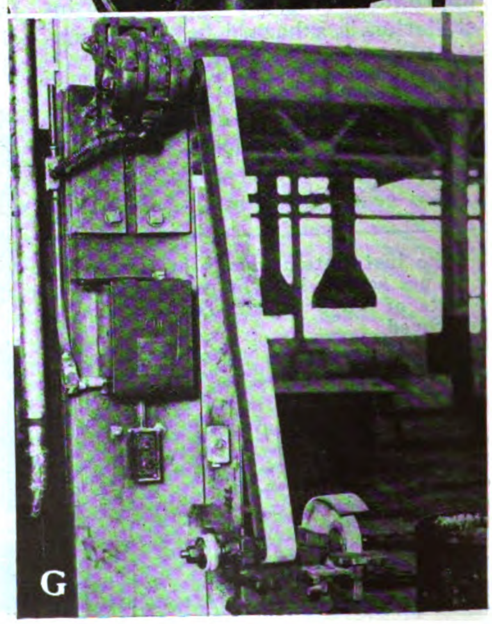
Compare the two installations at (2) and (3). Of course, the job shown in *D* has an automatic starter (3) which is easier to inclose, while the one in *E* has a hand starter; still a metal cover might have been put over the exposed starter with a slit for the starting handle to project through. Or fully-inclosed hand starters might have been used. Notice the convenient location of the push button (4) in *D* and also the use of flexible conduit (2) between the wall and the swinging motor frame.

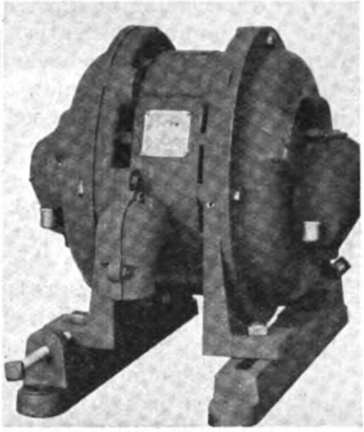
* * *

I'm willing to admit that there are lots of ways to do wiring, but I am sure that the job shown at (F) is not one of them.

Lamp cord may have a great variety of uses but I believe an installation like that shown in *G* has any "lamp-cord" outfit beat. Notice the convenient location of the push button in the job shown in *G*, the inclosed control panel, the neat use of the condulets, how the conduit is protected by being clamped close to the column, and the use of the flexible conduit and motor condulet. Here again is a case where a minimum amount of conduit and wire are used in an installation.







With a motor condulet like this no one can very well complain about the inconvenience of removing it in an emergency.

Remove three nuts and the entire condulet comes off leaving the motor just as though there never had been a condulet there.

The units of the equipment should be located so that the operator will not fall over them, or bump into them when doing his regular work. A field rheostat should be located convenient for the operator to reach; still it should not be in a position where it will hamper his movements or where there is any possibility of his work hitting it and causing a motor runaway. It may seem unnecessary to say such simple things; yet I have seen many cases of conduit running along the floor for a man to trip over, of controllers located near the aisles or in a rather exposed position where they might be hit by material being moved from one job to another, and of field rheostats placed where a man has to dodge around them every time he leaves his machine.

Another important safety feature is the provision for stopping a machine, especially in an emergency. This may be quite simple or complex, depending upon how quickly the machine must be stopped. In many cases a switch or device for disconnecting the motor is all that is required. In others, this means can be combined with a dynamic brake to shorten the time of stopping. Often these two methods are used with a shoe or band brake. The scheme used should be able to handle emergency as well as ordinary operating conditions and be positive and reliable. The point of control should be so placed that the operator can quickly reach it in an emergency. The best way to go about determining the location of the stop button is to imagine the various conditions that would require emergency stopping of the machine and then locate the button so that the operator can reach it under each of these conditions.

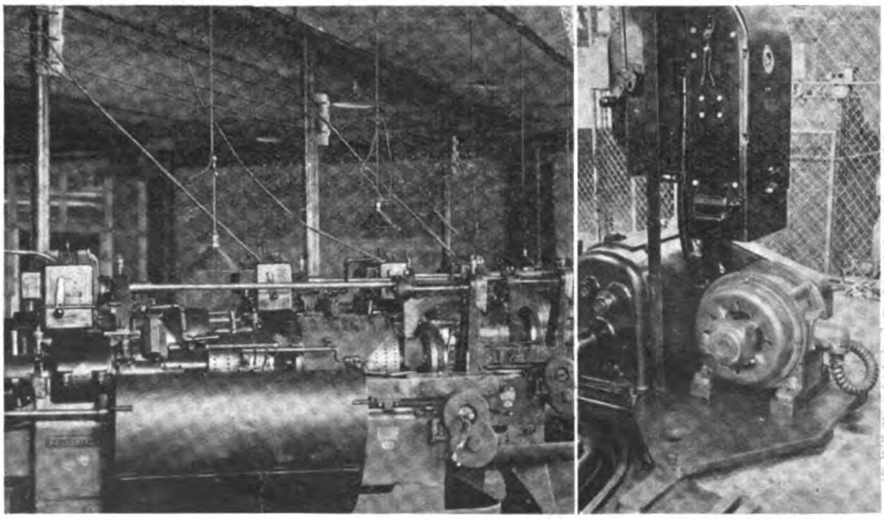
Another safety feature that should not be forgotten is the grounding of the conduit system, switchboard framework and motor frames. The conduit system should be grounded at a point as near the source of supply as possible. The motor frame may then be bonded to the conduit system. This furnishes the ground for the motor.

Continuity of Operation Should Be Maintained

The second important factor governing the installation of apparatus is continuity of operation or reliability. Lack of careful consideration of this factor shows up directly in production delays. In selecting the location for a motor, provision should be made to protect it from moisture, escaping steam, dripping pipes, oil, acid, alkali, chlorine and other gases, dust, lint and other injurious substances. In many cases, such as some machine tools, cranes and the like, this question has already been decided by the builder and a base plate has been provided. If the machine must be located where it is subjected to an injurious atmosphere or dirt, the motor must be protected either by especially-treated windings, enclosures, or a totally-enclosed motor such as a mill-type motor may be used.

The motor should be placed on a firm foundation. A steel bed plate or framework, or a concrete foundation are best. Such a foundation and proper alignment of the motor with gear or coupling will go a long way towards eliminating vibration and resulting troubles that have small beginnings but may grow into serious proportions with natural wear and tear.

Control panels, resistors and autostarters should be located in as clean a place as possible and should not be subjected to moisture, escaping steam, dripping pipes, oil, acid, alkali, chlorine or other injurious substances. Usually control apparatus can be located so as to be free from such influences and if not it can be enclosed and full protection provided. Resistors, however, must not be enclosed except with grille-work or a ventilated enclosure so that the heat may readily radiate. Resistors should not be wired with rubber-covered wire. The heat from the resistors soon melts the rubber and gives the job a very messy appearance and the insulating value is then destroyed. Flame-proof or asbestos wire should be used. In some of the



Here is another "temporary" job that became permanent.

Doesn't it make you mad when the boss asks you to make a temporary installation and then forgets that it was to be temporary? Temporary work is not a great deal cheaper than a permanent installation and it eventually costs a great deal more if the temporary job is permitted to remain as the permanent installation. The contrast between these two pictures ought to convince anyone of the error of a temporary installation.

plants I have visited I noticed that they used bare trolley wire for the resistor wires. These are stiff enough to support themselves without insulators and naturally air insulation around a wire is about as good as could be desired. On larger installations I have seen small busbar used similarly. These bare leads can only be used when the resistors and control panel are adjacent to each other and the enclosures of the panel and resistors can be extended to protect the bare conductors. Where the resistor is not adjacent to the panel it is necessary to use conduit and asbestos-covered or flameproof wire.

It goes without saying that the wiring should be protected at all points. There is only one sure way of doing this and that is by the use of metal conduit. All wiring in an industrial plant should, therefore, be run in either rigid or flexible metallic conduit, depending on the conditions of installation. The conduit should be continuous from outlet to outlet, or from fitting to fitting, and should be mechanically connected at each fitting. In other words, starting from the distribution cabinet the conduit should be attached thereto and if it goes to a pull box it should be attached to it rigidly by means of lock nuts. It should be fastened similarly at the enclosing cabinet surrounding the control panel. It is usually found best to end the rigid conduit running to the motor at a point on the wall, ceiling or floor, as the case may be, and run the final few feet to the motor condulet in flexible metallic conduit. This conduit can be moved out of the way when changing the motors.

This brings up another essential feature, which I consider very important—the motor condulet. It is quite customary to see a good conduit installation up to within a foot of the motor, the final foot or so being run in exposed wiring with clumsy taped joints at the motor terminals. Now since this is the point at which a lot of dirt and grease collects and the wires are often moved whenever an inspection is made, I think that this point in the wiring should receive a lot more protection than it usually gets. Many maintenance men advance the argument that a condulet fitting on the motor at the point where the terminals are brought out, causes trouble and takes up too much time in disconnecting and reconnecting a motor when a change is being made. I maintain that a careful inspection of the condulet shown on page 223 will completely refute this argument.

It goes without saying that the size of conduit and fittings selected should be large enough to pull all the required wires through without forcing and skinning them. This is always an easy matter since the National Electrical Code specifies the minimum size of conduit for a given number of wires. Conduit of 1½-in. diameter and larger should be supported at intervals not exceeding 11 ft., while conduit of less than 1½-in. diameter should be supported at intervals not exceeding 6 ft.

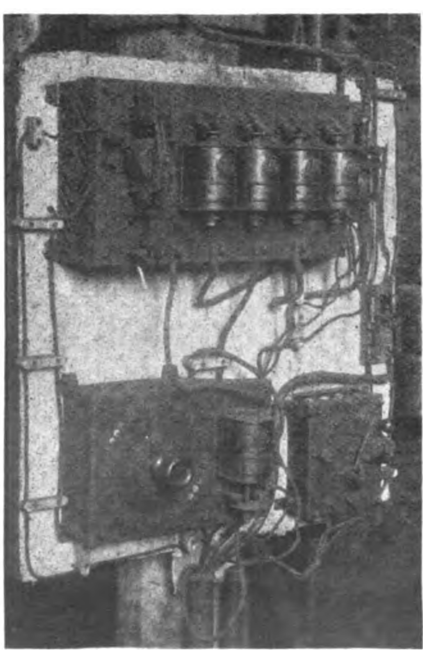
Sharp bends in conduit should be avoided wherever possible and standard elbows or condulet fittings used instead. Where necessary to form bends, the conduit must not be flattened or kinked. The National Electrical Code states that the radius of the curve of the inner edge of any bend shall be not less than 3½ in.

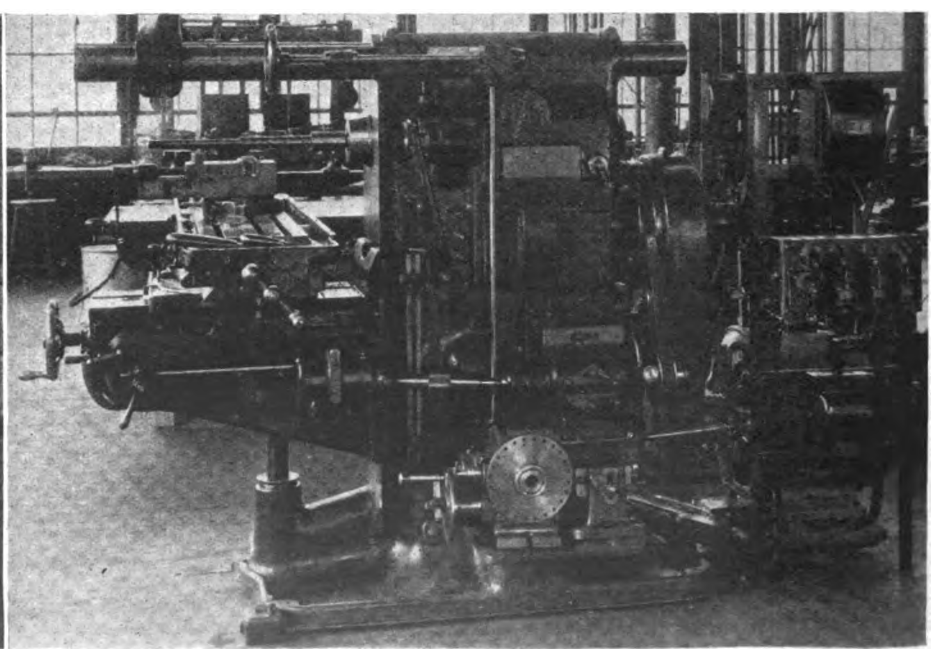
In dye or bleaching rooms or any other location where the conduit is exposed to acid fumes and excessive moisture, the conduit should be painted before installation with two protective coats of red lead and linseed oil or other protective paint. After installation, all abrasion marks should be repainted. Pipe straps, conduit supports, junction and cutout boxes should be given the same treatment as the conduit.

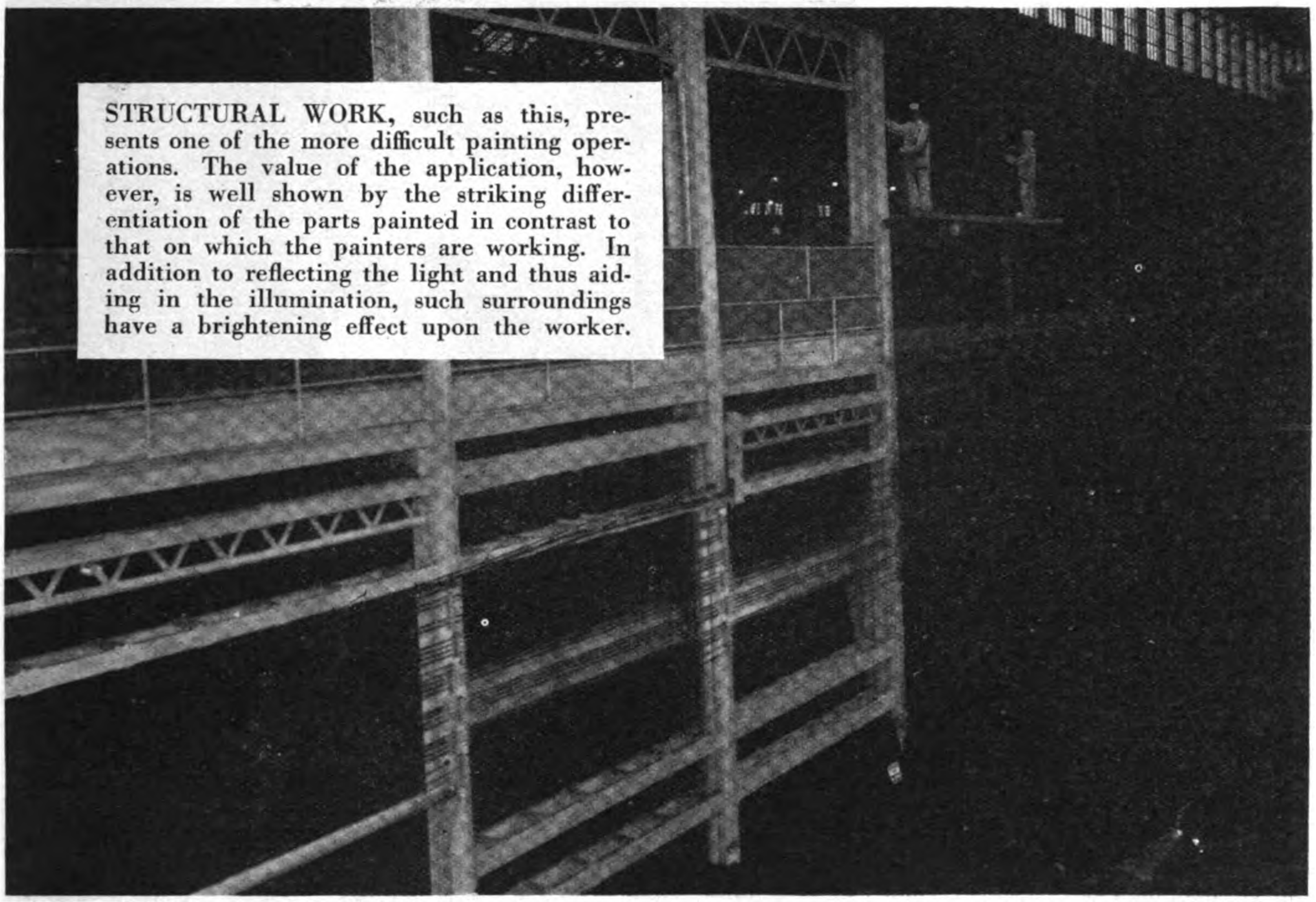
On conduit runs more than 500 ft. in length, and using conduit over 1 in. in diameter, expansion joints should be provided to allow for the expansion and contraction of the conduit. This is a point often overlooked where conduit is exposed to the hot sun or where temperatures are high. *(Continued on page 259)*

The installation on the left worked, but I wonder how long it continued without trouble?

This installation may have run a long time but don't you think it would have carried much more credit for the man who put it in if it had been as good as the one shown at the right? Take a look at the open knife switch of one and the safety switch of the other; at the open wiring and the conduit work; at the unsightly wood "bulletin board" covered with asbestos and the steel frame work for holding the control equipment. Also notice the convenient location of the push button on the floor at the operator's feet, in the picture at the right. Now I don't claim that the job at the right is perfect. You, with your wide experience, can undoubtedly pick out lots of flaws; for instance, the panel with the relays and contactor should be enclosed to keep it cleaner and to prevent danger of touching a live part. But don't you think that you would rather have in your plant the installation shown in the right-hand picture, than that shown on the left?







STRUCTURAL WORK, such as this, presents one of the more difficult painting operations. The value of the application, however, is well shown by the striking differentiation of the parts painted in contrast to that on which the painters are working. In addition to reflecting the light and thus aiding in the illumination, such surroundings have a brightening effect upon the worker.

You Can Get

Better Illumination Without More Lamps

In Many Instances and in Others Even Reduce Present Wattage When You Properly Direct Available Light Rays and Provide Proper Reflecting Wall and Ceiling Surfaces

By W. WENDELKEN

Illuminating Engineer, Works Electrical Dept., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

WHITE and light colored paint applied on the inside surfaces of buildings plays an important part in the utilization of the light output of the lighting units and thus materially assists in the resultant illumination. Also, when laying out a lighting system for any form of building, whether home, office, or shop, it is especially important to know just what color scheme is to be used on the surrounding surfaces, for this will influence the kind and type of reflector and lamp equipment to be used.

The efficiency of a lighting system, moreover, depends not only on the lighting units themselves, but also on the reflecting properties of the surrounding surfaces, mainly the walls and ceilings. The ceiling should be of a light tint, especially when indirect or semi-indirect units are used, for, as can be readily appreciated, with a totally indirect unit all light obtained on the working plane is reflected from the ceiling, and if this happens to be of a dark shade or dirty the efficiency of a unit falls off rapidly. Likewise, it is often possible to obtain better lighting in a room, even though equipped with poor lighting units, when the surrounding surfaces have been finished with the proper light-

MR. WENDELKEN Points Out That—

To OBTAIN proper lighting no one thing will aid more than a coating of good white paint spread over the inside surfaces of the shop or building. With a correctly designed lighting system and liberal use of white paint applied periodically to all surrounding surfaces, the total wattage of a system can be reduced as much as 25 per cent, depending upon the intensity of the illumination required. Even in old installations where the walls are exceptionally dirty and the lighting equipment inefficient, immediate gains of from 10 to 25 per cent are obtainable by brightening things up with a good coat of white paint.

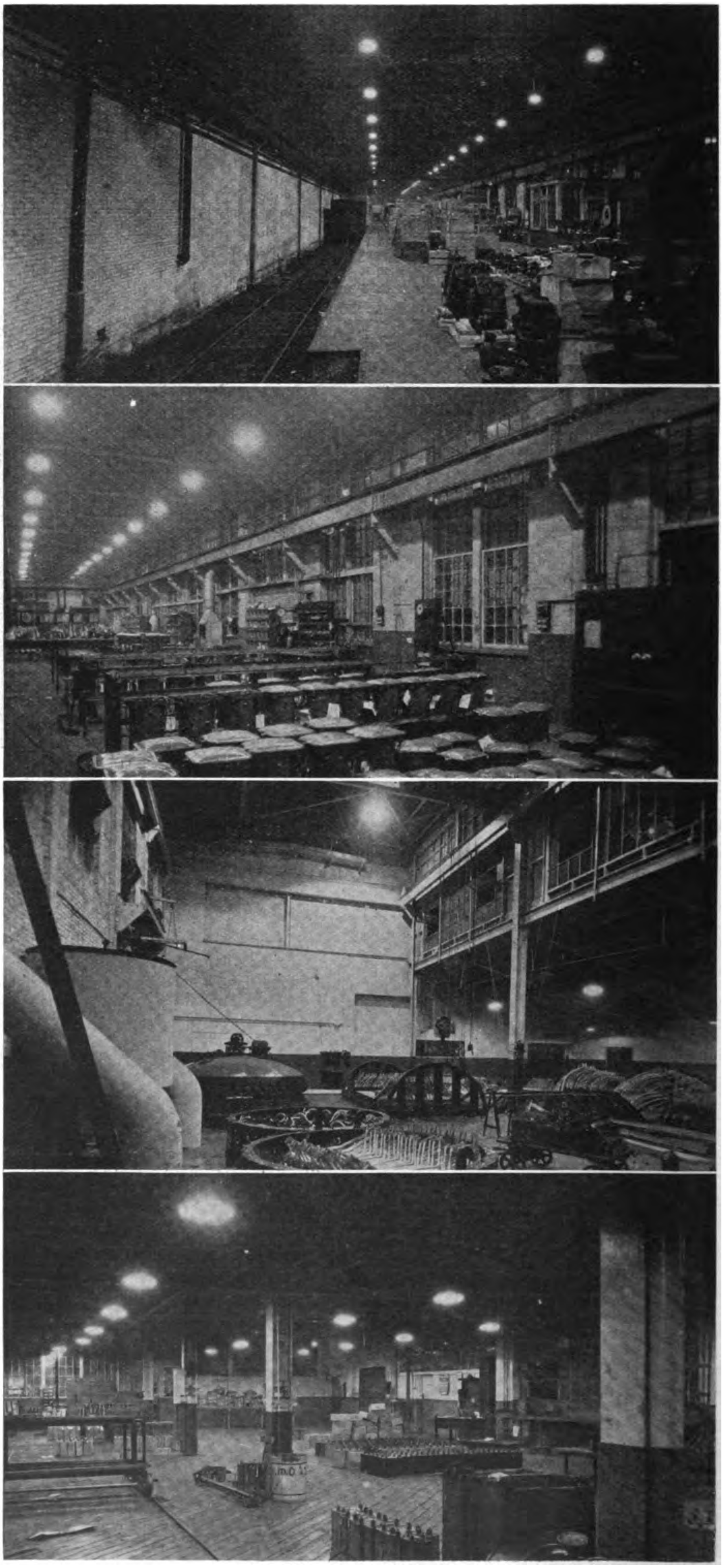
In a building where no scaffolding is required and the work is mostly straight painting, brush work will cost approximately 30 cents per 100 sq. ft. Where scaffolding is necessary about 12 per cent should be added. Spray work can usually be figured to run about 50 per cent of brush work. The expense incurred by installing good lighting and keeping things clean and well painted will be easily paid for by the results obtained.

colored tints. The inefficiency of the lighting units is thus compensated by avoiding absorption on the reflecting surfaces.

In industrial lighting, such as the lighting of shop buildings and manufacturing plants, the value of good lighting is a tangible asset that comes back to the employer in the form of increased efficiency among employees and results in greater production and decreased labor turnover because of the more cheerful appearance and atmosphere. In a well-lighted shop there is a more pronounced mental alertness among the employees, who, as a result, are able to do more and better work. By proper lighting, dark corners, dark passage ways, elevator landings, stairways and other similar places are made safer, thus reducing the accident hazard which is always present in a marked degree with poor lighting.

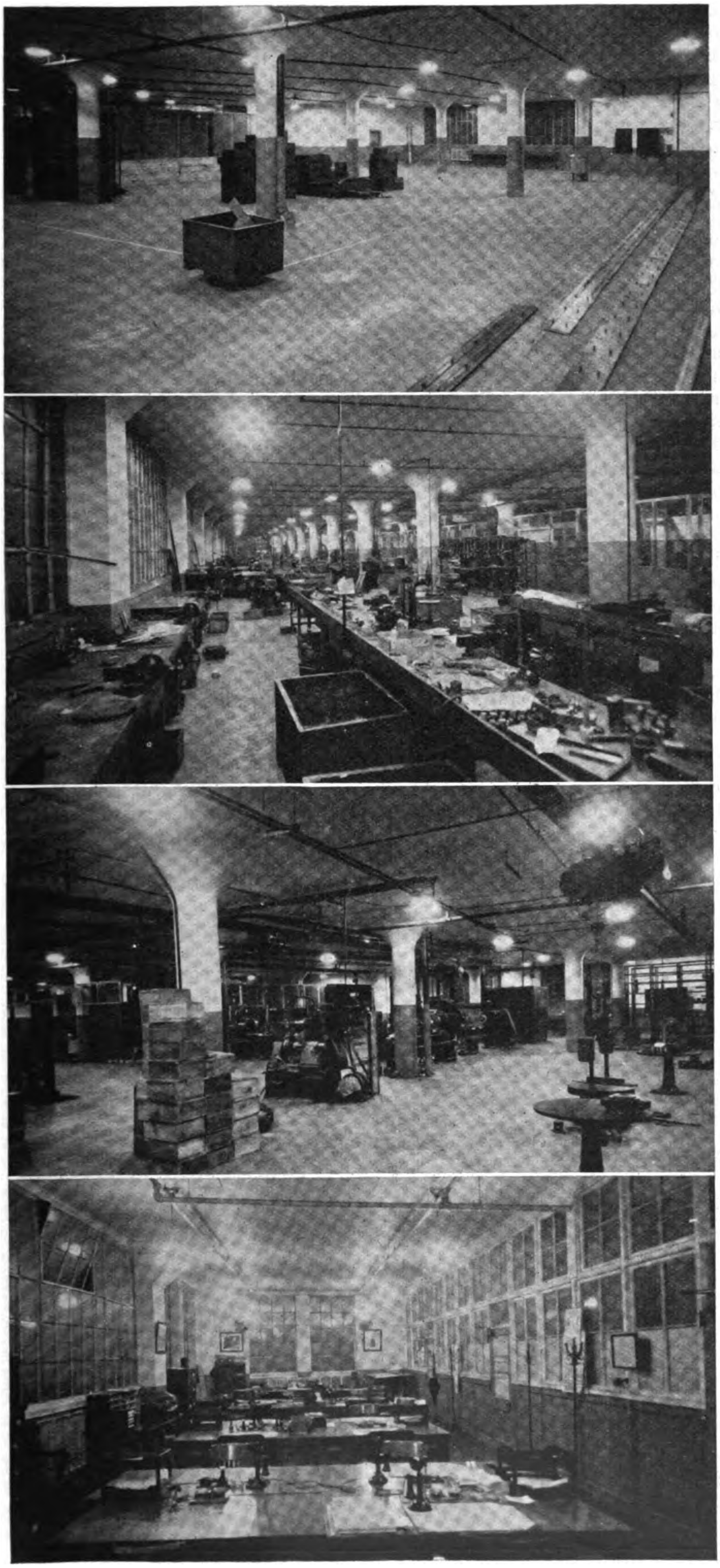
To obtain proper lighting no one thing will aid more than a coating of good white paint spread over the inside surfaces of the shop or building. With a correctly-designed lighting system and the liberal use of white paint applied periodically on all surrounding surfaces, the total wattage of the system can be reduced as much as 25 per cent, depending on the intensity of the illumination required. Thus, it will be seen that with large installations the saving in wattage alone will be considerable. Even in old installations where the walls are exceptionally dirty and the lighting equipment inefficient, immediate gains of from 10 to 25 per cent are obtained by brightening things up with a good coat of white paint. In this case it would be possible to reduce the size of the lamps somewhat and still obtain the same intensity as before. The percentage of improvement will vary, of course, depending on the conditions of the old surfaces before making the change.

It is generally advisable to paint all interior surfaces and maintain



Four views showing the value of white paint applied to the walls and ceiling.

All of these photographs were taken in the Westinghouse Works at night by the light from the lighting system only. Even though some of these buildings have high ceilings, the upper part of the views show a haze instead of a deep black, as is ordinarily found in illustrations where the paint on the ceilings does not have high-reflecting value. It is ordinarily difficult to get anything but a deep black background in such views as this without the aid of a flashlight or other illumination, besides that given by the lighting system.



them in respectable appearance anyway, for the good effect that light surroundings have upon the working force. If white paint is used, it may be necessary to renew it somewhat more frequently than if darker tints are used. However, in practically all cases it will be found that the benefits from better illumination and its effect on the workers will more than overbalance the additional expense.

Because of the effect of the surroundings and of the type of work done in the building it is very difficult to set a definite time interval between paintings. In a dirty atmosphere as in the Pittsburgh district, for example, it would probably be necessary to repaint about every two and one-half or three years. In cleaner districts and at cleaner work, this time should be almost doubled. The item of expense of repainting likewise enters into the determination of an advisable period between repaintings. This question must be answered by the judgment and experience of those in charge.

Our company makes no effort to clean painting jobs in the shops as the expense involved would very likely justify repainting. The labor cost, which is one of the largest elements of cost in painting, and the difficulty of erecting scaffolds and staging, would be about as great for a cleaning operation as for repainting. Some of the offices, however, where the finish is not so dirty and where the rooms are not so large, are cleaned periodically. In cases like this, it is possible to save time and money by cleaning a surface instead of repainting.

It is always advisable to use a good quality of paint even though it is not exposed to the weather and will last almost indefinitely. The greatest depreciation is, of course, in reflecting value. The experience at the East Pittsburgh Works has shown a decrease of about 10 per cent in reflecting value in the first three or four months; after this, however, the decrease is not so rapid. Ordinarily, a depreciation of about 20 per cent the first year and

Four views of white-painted ceilings where the lighting unit is placed close to the ceiling.

In the upper three views metal reflectors are used. The illustrations easily show the reflecting value of the white ceiling in these cases. The lower view of an office shows an installation of Westinghouse "Sol-lux" luminaires. In offices at the Westinghouse plant the paint is sometimes cleaned, although no effort is made to clean it in the shops.

10 per cent each for the second and third years is expected. This, of course, may be greater or less according to the conditions, as previously expressed.

Any of several good grades of inside paint on the market can be used as well as one or two brands that are sold and advertised especially as an aid to factory lighting. The cost of any of these is not excessive and they not only aid wonderfully in securing illumination but also form a protective coating on the surface painted, thus performing a dual purpose. Even a good grade of white wash will serve for small outbuildings and sheds where appearance is not so essential. Whitewash may be applied at less expense but it is not so lasting.

As to the kind and color of paint to be used, several have been tried; but for all general purposes, such as the inside of shop buildings, manufacturing plants and other industrial applications of this kind, a good grade of white inside gloss paint is most satisfactory, with a medium gray border about 4 ft. high from the floor running around the room. This gives a good appearance and is standard practice with several companies.

The gloss will not be objectionable after a few days' service, unless in the direct line of vision, and this kind of paint stays clean longer even where subjected to smoke or dirt. Flat paints will be found to be more suitable in a small enclosed room where the occupants must continually gaze at the wall. Here the glare from a gloss paint would prove disagreeable. In general, however, a gloss paint will prove better and longer lasting, and for this reason is to be recommended for all places where it is suitable, especially buildings of large area and where frequent painting is not convenient.

For the inside of small rooms, store buildings, office buildings, residences and the like it is almost compulsory to use a flat paint with some suitable color scheme such as light cream for the ceiling and light grey, tan, buff or any suitable light shade for the walls. Buildings of this description are not subjected to dirt as much as shop buildings are and a more subdued color scheme using flat paints will be found to be much more appropriate.

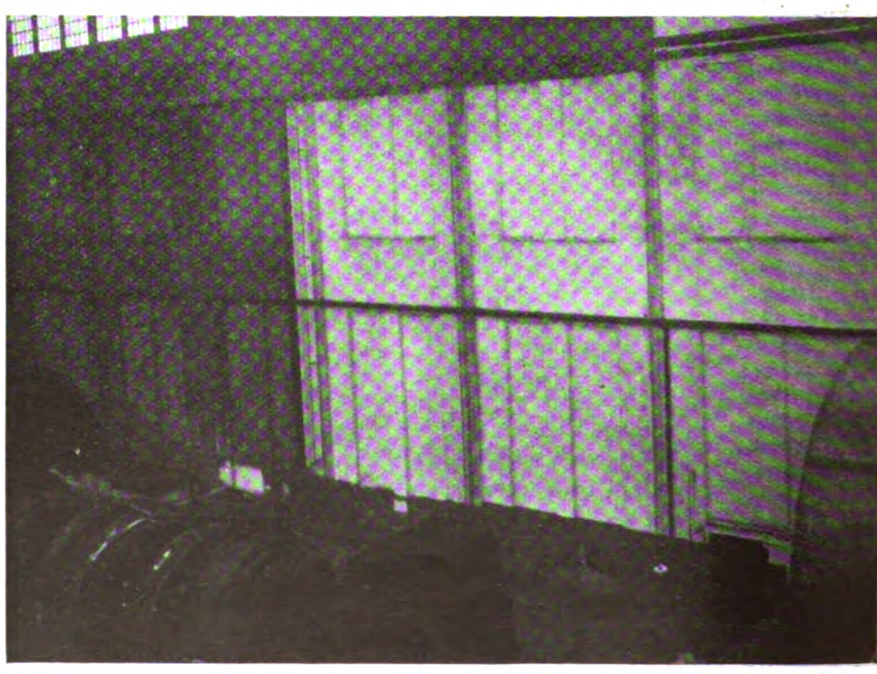
Paint can be applied either by brush or spray, depending on conditions. The spray is commonly used where large areas are to be covered and where the quality of the work is not so important. Good quality painting can be done by spray by experienced operators if they take the necessary time and care. In offices and similar places it is necessary to paint with the brush but in large areas where there is no objection to the paint permeating the air, the spray is the best method to use. This is not objectionable in most shops as the machinery on the floor can be covered over during the spraying period and protected from the paint which escapes into the air from the spray. By using the spray the job can be done at about one-half the labor expense of brush work and in about half the time. There are, of course, some places which can only be covered with the brush. Conditions and structural details of the building will dictate the best method to be used.

The total cost of a painting job will vary according to the structural features of the building, the cost of the paint, whether scaffolding will be required, whether brush or spray is to be used, and, lastly, whether the job is to be done on straight time or overtime.

In a building where no scaffolding is required and the work is mostly straight painting, brush work will cost approximately 30 cents per 100 sq. ft. Where scaffolding is necessary about 12 per cent will have to be added to this figure. Spray work can usually be figured to run about 50 per cent of the cost of brush work. These figures apply to work on straight time and at the price of labor as paid in the Pittsburgh District at the present time. They will vary somewhat according to the labor rate and details of the building to be painted but can be taken as fairly accurate for estimating.

The night photographs accompanying this article will give the reader some idea of the advantages to be obtained from the use of paint. These were all taken throughout the works of the Westinghouse Electric & Manufacturing Company and show the liberality of the use of paint. These photographs were all taken by light from the lighting system only and have not been retouched. A good night photograph of a lighting system is hard to obtain unless the best of conditions prevail. In these pictures the paint jobs were only from one to three months old, and for this reason the majority of the pictures are exceptionally clear in detail. Without the assistance of the white paint it would have been difficult to obtain pictures anyway approaching these.

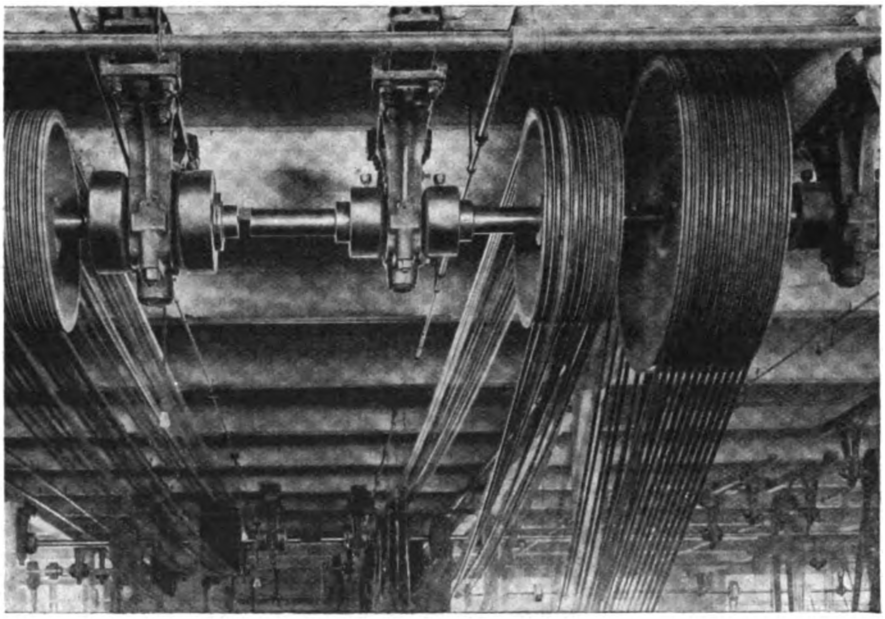
It is the writer's experience that the money spent for painting and good lighting is one of the best investments that can be made for increased efficiency and production. People unconsciously react to good lighting conditions. No man can do his best under poor light nor will he be contented with such surroundings.



A before and after view showing the contrasting value of white paint.

Straight work, such as this, even though it requires the use of scaffolding or slings, may, in many cases, be spray painted. If painting must be done at night so that it will not interfere with crane service, it often adds to the cost.

THIS IS the second and concluding article covering lineshafts, hangers and hanger bearings. In a group drive successful operation depends largely upon alignment of shafts and low friction loss in bearings. Misalignment increases the power consumption as it requires bending and straightening the shaft at each revolution. In some cases the power required to do this has been about 50 per cent of the entire operating load. When shafts squeal or groan on starting or stopping it will pay to look into the alignment. Better bearings may decrease this friction loss, but alone they will not compensate for misalignment of the lineshaft and neglect of proper attention to lubrication.



Special hanger bearings with double ball races have been inserted in this rope drive lineshaft installation.

Some Types and Applications of

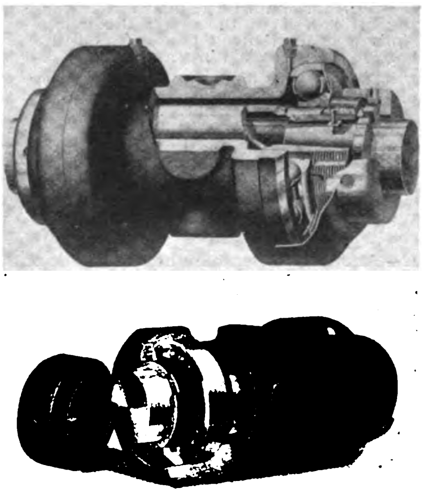
Babbitt, Ball and Roller Hanger Bearings

Together with Various Methods Employed for Spreading the Lubricant Over Bearing Surfaces and Ways to Reduce Friction Losses

By FRANK E. GOODING
Associate Editor, Industrial Engineer

GROUP DRIVES, to be economical, require, in addition to a driving unit of sufficient power to handle the starting and running loads, a careful selection and installation of the lineshaft, hangers and bearings. In the April issue an article on "Lineshafting and Hangers" discussed the first two of these power transmission units. This article will take up some of the different types of bearings for use in lineshaft hangers.

Upon the hanger bearings rests much of the responsibility for satisfactory and economic operation of a lineshaft. Bearings are of various types but in general are classified, according to the method of applying the lubricant, into either plain, capillary, ring oiling, collar oiling, or are provided with roller or ball bearings. These types of bearings, with the exception of roller or ball bearings, are made by the various manufacturers of hangers to suit the different types of hangers and pillow blocks which they produce. Each manufacturer specializes usually on some of these types. Roller or ball bearings are usually made by companies which specialize in them alone. The group of bearings shown on page 230 illustrates some of the general types. Bearings similar to those illustrated are in most cases produced by several different manufacturers. Most of these types of bearings are also used with pillow blocks.

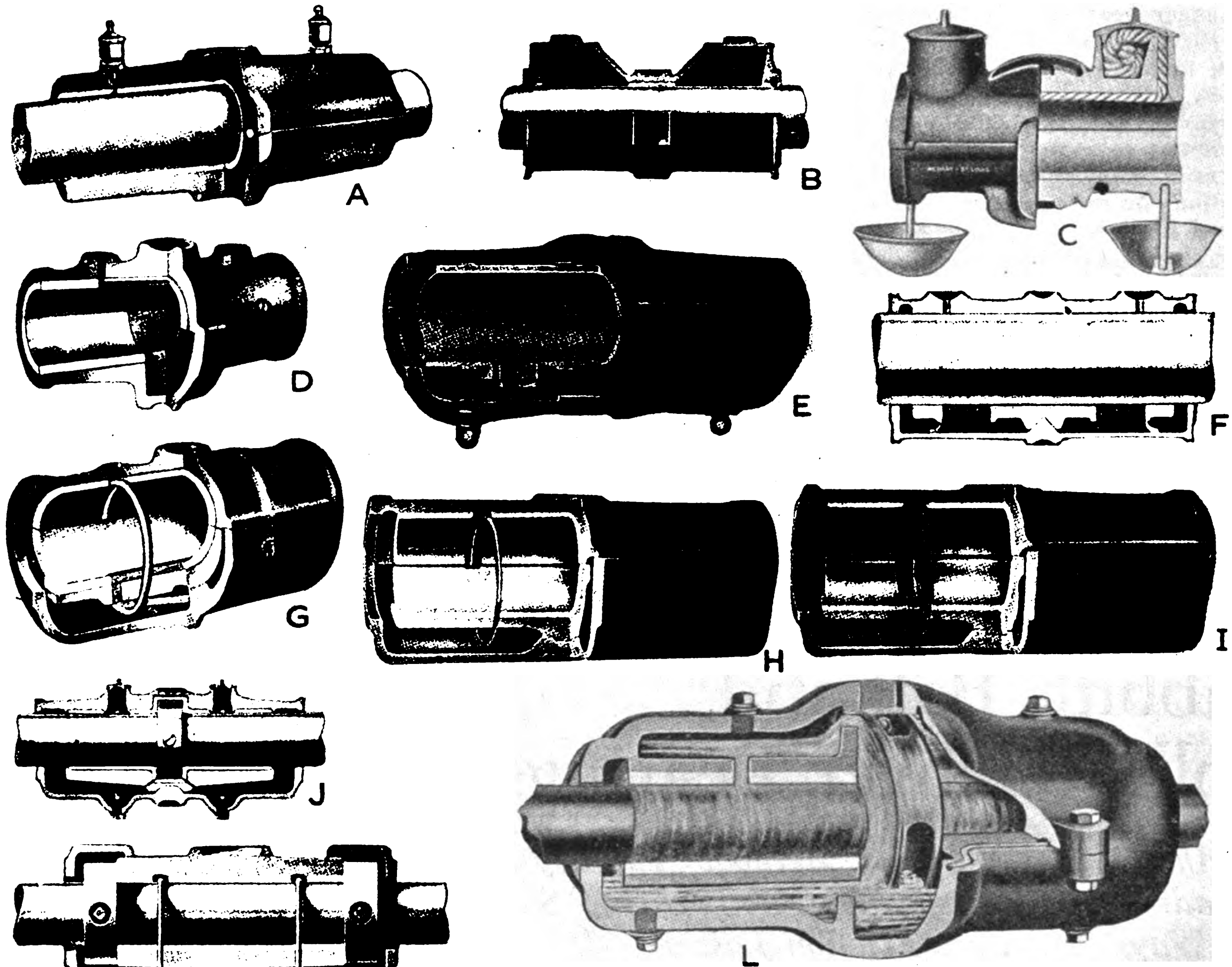


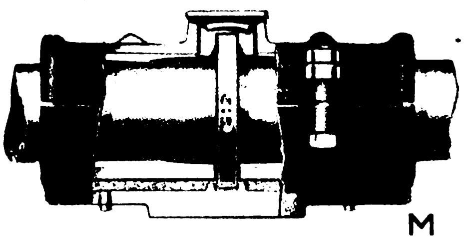
A cut-away view of two types of ball-bearing boxes for lineshaft hangers.

The manufacturers of both of these types of ball-bearing hanger boxes provide them with various casings so that there is a type which may be used in each of the various types of hangers. In this way they may be installed at a minimum cost as they can be used with standard hangers. On shop installations it is only necessary to remove the old bearings and replace with new

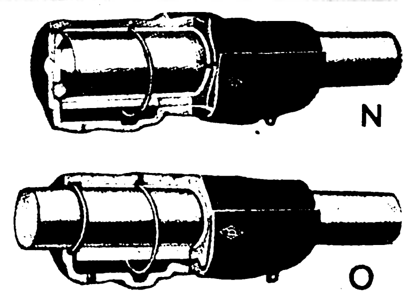
Plain bearings with babbitt surfaces are often fitted with grease cups and used for low-speed work. Also, because of their lower cost such bearings are frequently used in temporary installations and in plants which operate only a few weeks or months during the year, as in some canning plants and similar places. They are also used on small machine countershafts with a loose pulley where the shaft and bearings are not operating full time. While these bearings are usually split, some plain bearings are made solid to slip over the end of the shaft, although ordinarily, these are used only on countershaft installations. Ball-bearing loose pulleys are being quite widely used on countershafts, as has been mentioned in previous articles.

A poor bearing not only wastes power but also is likely to cause trouble and can tie up an entire job if placed in an important location, as on the headshaft or on one of the principal lineshafts. A consequent interruption of service may easily





These illustrations show some of the various types of bearings for shaft hangers. Various manufacturers produce adaptations of these different types. No effort is made in these illustrations to show the grooving of the babbitt bearings.



A—On slow-speed work where plain bearings are desirable, this type of bearing with grease cups is frequently used. This particular bearing is fitted with a round wick extending the full length on each side to spread the lubricant. Grease bearings are often used where the bearing pressure is high and the speed low.

B—These bearings are provided with two large grease boxes that feed the lubricant directly on about one-half the journal area. When filled with one of the several well-known fibrous greases and packed with yarn, as shown, a filling will last from six months to a year.

C—A wick-oiling bearing, such as this, is often used on shafts revolving at moderate speeds and carrying loads that are not excessive, as on countershafts. The wick extends from one oil reservoir across to the other and so distributes lubricant practically the full length of the bearing.

D—This is a combination of a plain oiling bearing which is provided with a piece of felt in the reservoir in the bottom to feed lubricant by capillary action.

E—Another capillary oiler in which the oil is fed to the shaft through a slotted wooden block held against the bottom of the shaft by a spring.

F—Here the oil is supplied to the journal through wicks by capillary action. These need be oiled about once a month and emptied and refilled about every three to six months, according to the speed and surrounding conditions.

G—This bearing combines a ring oiling system with a capillary auxiliary. Wipers at both ends return oil on the shaft to the reservoir.

H—Another type of the ring-oiling bearing. The bottom of the oil reservoir is flat, which prevents overturning when removed and does not leave any grooves for sediment to form.

I—Sometimes chains are used for oiling bearings instead of rings. With chains, a heavy oil cannot be used satisfactorily.

J—Here a concealed thrust collar is used in connection with ring-oiling bearings to prevent lateral movement in textile, rubber, and similar mills where a loss would result from oil being thrown from an outside set collar.

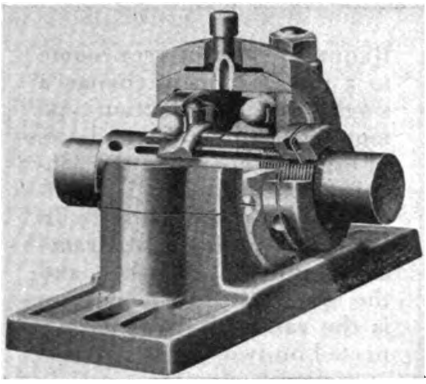
K—Another type of ring-oiling bearing where inclosed double collars are used to take the end thrust of lineshafts in each direction.

L—This shows the operation of a collar-oiling hanger bearing. The collar carries the oil from the reservoir to the top, where it is distributed to the bearings.

M—A sectional view of still another type of collar-oiling bearing box.

N—Bearings with a closed end, which may be of any type of lubrication, are frequently used at the ends of short countershafts and eliminate the necessity for employing collars to prevent side motion. Although this is a ring-oiling bearing, other types of lubrication may be used.

O—Frequently when bearings are used in dusty and dirty places like cement mills, brick mills, paint mills, brick yards, and other similar places, a dust-proof collar is placed in the end of the bearings as shown here. This may be used with any type of bearing. Sometimes a packing ring is inserted at the end of the bearing to prevent oil leakage.

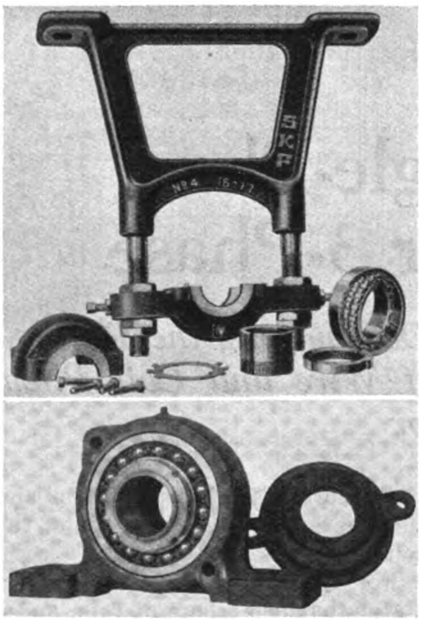


A cut-away view of a double-race, ball-bearing, self-aligning pillow block.

This pillow block combines the value of the self-aligning principle and low friction loss in the heavy service required of pillow blocks in power transmission drives.

cost more than the difference between good and cheap bearings.

Bearings which depend upon capillary action for lubrication use wicks, felt or special slotted wooden blocks which dip into the oil and feed it to the surface of the bearings by capillary action. Sometimes wicks are used to distribute grease lubricants. In wick self-oilers the wick is usually placed on the top of the bearing and above the shaft, although some types feed through the wick to the bottom or sides of the bearing. An advantage of wick bearings is that they strain the oil before it is fed to the shaft. However, if a shaft is idle for some time the oil on the wick is likely to harden so that the entire wick must be changed before the shaft can be put

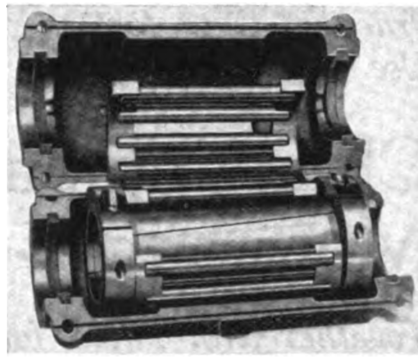


Ball bearings are also used in shaft hangers and in pillow blocks.

The top view shows one method of getting a four-point adjustment in a shaft hanger. Ball bearings should be slipped over the end of the shaft and have a sucking fit instead of a tight force fit because forcing the bearing will expand the inner ball race and cause excessive pressure and wear on the bearings. Ball-bearing pillow blocks are not only used on shafting but also in many machines.

into operation again. Babbitt is most commonly used for these types of bearings.

Ring-oiling bearings, as *G* and *H* on the opposite page, are commonly used not only for lineshafts but on many machines. In most cases, as illustrated, the bearing is provided with two rings. As the shaft rotates it carries the rings up over the



Another type of roller-bearing shaft hanger box.

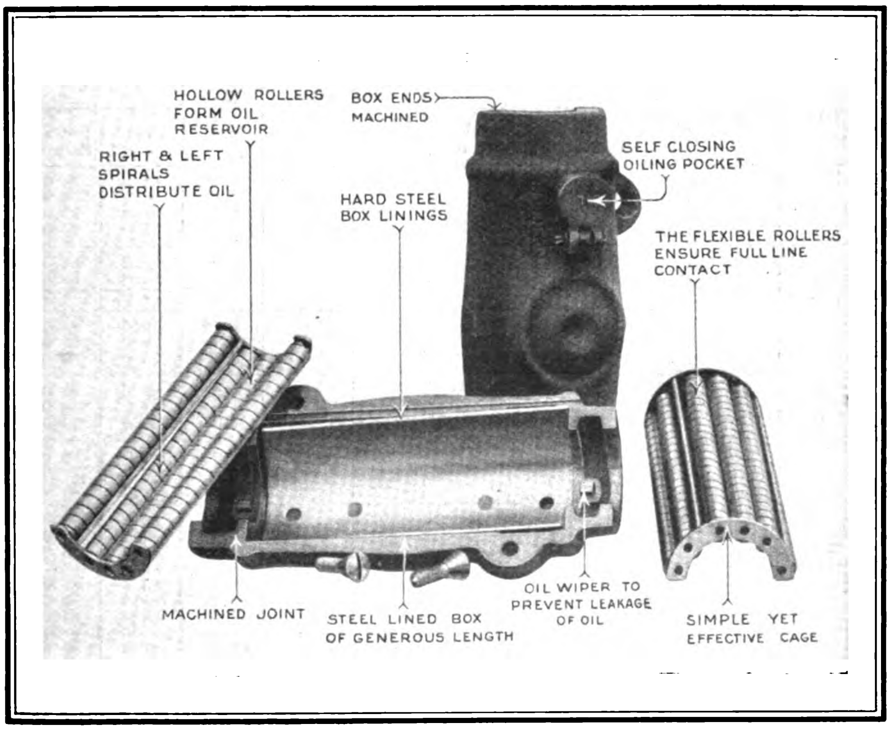
Here the bearing fits on a sleeve attached to the shafting and so may be used over a spot where the shafting has been badly worn. This also may be obtained in different types of casings to fit the various types of shaft hangers.

shaft and distributes the oil which adhered to the ring. In some types chains, as shown at *I*, are used instead of rings.

In collar-oiling bearings there is clamped around the shaft a collar which carries the oil with it from the oil reservoir in the bottom of the bearing and allows it to flow up over the top of the shaft, as shown at *L*. This is a positive-acting bearing and there is no danger of its not operating as long as there is oil in the reservoir. Ring bearings sometimes stick and do not rotate and so stop carrying oil for lubrication. Generally this collar is split and clamped over the shaft. In some cases, however, a solid collar is shrunk around the shaft and serves not only for oiling but also as a thrust collar or bearing. The collars shown in illustrations *J*, *K*, and *M* are designed to take care of end thrust.

Unless a bearing reservoir is filled too full it should not drip oil. However, a dust-proof ring or packing at the end of the bearing not only prevents the leaking of oil but also prevents dust from working into the bearings. Where bearings are used at the end of a shaft it is always best to use closed-end bearings as no dust can get into the oil reservoir.

Most of these hangers are of what is known as the ball-and-socket type which fits into a two- or four-point adjustment hanger and gives some freedom *(Continued on page 257)*



Details of construction of a roller shaft bearing.

These bearings are split and may be placed on the shaft without removing the shafting. Among the advantages claimed for roller bearings are that they require lubrication less frequently, cause less friction, and so save power. These are made in various shapes of casings so as to fit in the more standard types of hangers.

Practical Data for Use When

Changing Single-Phase Motors to 2-or 3-Phase

Together with Tables for Determining the Rating, Turns per Phase, Sizes of Wire and Coil Pitch When Rewinding the Stator

REQUESTS FREQUENTLY come to a repair shop to change a single-phase, induction-type motor to two- or three-phase, in order to eliminate the centrifugal switch used in starting a split-phase motor. In such a case the core, frame and rotor is available and the question that comes up is the rating that can be expected on two- or three-phase operation. In this article Mr. Roe gives step-by-step details for these changes together with handy tables for use on a wide variety of jobs.

By A. C. ROE.

Repair Superintendent, Detroit Service Dept., Westinghouse Electric & Manufacturing Co.

A SINGLE-PHASE motor frame is 1.5 times the size of a corresponding two- or three-phase motor of the same horsepower and speed, which means that when changing from single-phase to three- or two-phase with the speed remaining the same, the single-phase horsepower rating can be increased 1.5 times.

There is another and better method for determining what horsepower a given frame is capable of developing, that can be used when an old core on which the winding has been removed is available. This method makes use of the number of cylindrical inches in the core, using the inside diameter, which is the bore B squared, times the length of the core. Thus $(B \times B \times L)$ determines the maximum horsepower rating of any frame.

In Table I are given the minimum cylindrical inches allowance for each horsepower rating from ¼ to 7½. The values given are for cores of four-pole, 60-cycle, 1,800-r. p. m. motors. In a footnote under Table I the formula for determining the cylindrical inches required for six- and eight- and ten-pole, 60-cycle motors is given.

Table II gives some values taken from rewound motors. These values can be used for comparisons or checks.

In Table III are given the cylindrical inches of stators having a bore of 2½ in. to 9½ in., in steps of ⅛ in., and the length of core from 1 in. to 4 in. The first column gives the bore in inches, the second column the value of bore B squared $(B \times B)$; then each succeeding column gives the value of $(B \times B \times L)$ or cylindrical inches, corresponding to the bore at the left of the line and the length of core at the head of the column.

For example, assume we have a stator that has a bore of 6 in. and a core length of 2½ in.: What are the cylindrical inches? First locate the figure 6 in the bore column in Table III. Then look along this line until under the heading of 2½ in. we find 90, which is the cylindrical inches of this core. According to Table I this core is good for 3 hp. at 1,800 r.p.m., 60 cycles; or 3 ÷ 1.5 equals 2 hp. at 1,200 r.p.m.; or 3 ÷ 2 equals 1.5 hp. at 900 r.p.m.; or 3 × .365 equals 1.095 hp. at 720 r.p.m. The above procedure can be followed for determining the horsepower rating of any core within the limits given.

The next step is to determine the number of turns, size of wire, and coil pitch. To get the turns, the flux per pole per phase must be figured. This is done by the use of the formula $(0.636 \times S_1 \times L \times Bm)$, where S_1 is the pole pitch which is equal to (bore × 3.14) divided by number of poles. Values for S_1 are given in Table IV; L equals length of core. When length of core is stated, it means actual length of iron, not including ventilating ducts or end-plates. Bm is the magnetic density in the air gap in lines per sq. in. and runs from 20,000 to 30,000 for motors up to 7½ hp. with closed slots. A good average value for four and six poles is 25,000 lines per sq. in.

Ampere Ratings, Efficiency and Power Factor for Two- and Three-Phase, 60-Cycle, 220-Volt, 40-Deg. Motors

Three-Phase					Two-Phase				
Hp.	Poles	Amp. per Terminal	Per Cent Efficiency	Per Cent Power Factor	Hp.	Poles	Amp. per Terminal	Per Cent Efficiency	Per Cent Power Factor
¼	4	.90	71.0	76.0	¼	4	.82	69.0	75.0
½	4	1.61	76.0	80.0	½	4	1.45	74.0	79.0
½	6	1.90	72.0	73.0	½	6	1.71	69.0	72.0
½	8	1.92	71.0	72.0	½	8	1.80	68.0	70.0
¾	4	2.33	77.0	82.0	¾	4	2.09	75.0	81.0
¾	6	2.48	75.0	80.0	¾	6	2.17	73.0	80.0
¾	8	2.65	73.0	71.0	¾	8	2.32	72.0	78.0
1	4	2.95	80.0	83.0	1	4	2.65	79.0	82.0
1	6	3.02	79.0	81.0	1	6	2.81	78.0	81.0
1	8	3.60	75.0	71.0	1	8	2.97	76.0	80.0
1½	4	4.42	82.0	82.0	1½	4	3.82	82.0	82.0
1½	6	4.48	81.0	80.0	1½	6	3.88	81.0	80.0
1½	8	5.15	77.0	74.0	1½	8	4.01	80.0	79.0
2	4	5.7	82.0	87.0	2	4	5.0	81.0	86.0
2	6	6.0	79.0	81.0	2	6	5.3	78.0	79.0
2	8	7.9	78.0	63.0	2	8	7.4	77.0	59.0
3	4	8.1	86.0	87.0	3	4	7.2	82.5	86.0
3	6	8.7	83.0	79.0	3	6	7.5	82.0	83.0
3	8	9.7	81.0	73.0	3	8	8.5	81.0	73.0
5	4	13.1	87.5	87.0	5	4	11.5	85.6	87.0
5	6	13.6	85.0	86.0	5	6	12.1	85.0	82.0
5	8	14.1	84.0	82.0	5	8	12.6	83.0	81.0
7½	4	19.1	87.0	88.3	7½	4	17.1	87.0	87.0
7½	6	19.5	86.0	87.0	7½	6	16.8	87.0	85.0
7½	8	20.6	85.0	82.0	7½	8	20.0	86.0	82.0

For an eight-pole motor it would be 20,000. Then the flux per pole for a 6-in. by 2½-in. stator would be figured as follows: S_1 according to Table IV for four poles is, 4.712. Then the flux equals (0.636 × 4.712 × 2.5 × 25,000) equals 187,250 lines.

To help in estimating the size of wire required the table on page 232 is given. This table gives the ampere rating, efficiency and power factors for 220 volts. For 110 volts multiply these values by 2; for 440 volts divide by 2; for 550 volts multiply by 0.4.

In the following examples we will use 80 per cent coil pitch, or coil pitch equals (1 and 1 plus number of slots divided by number of poles times .80). For forty-eight slots and four poles, the coil pitch is (1 and 1 + 48 ÷ 4 × .80) equals

Table I—Minimum Cylindrical Inches

These values are per Hp. for 4-pole 60-cycle, 1800 r. p. m. motors.

Hp.	Min. BxBxL	Circ. Mils per Amp.
¼	12.00	320
⅜	20.00	375
½	25.00	450
¾	30.00	475
1	40.00	500
1½	55.00	525
2	75.00	550
3	90.00	600
5	120.00	650
7½	200.00	675

Φ = 0.636xS_1 xLxBm.
Bm = 20,000 to 35,000 lines per sq. in.
S_1 = Pole pitch = (Bx3.14) ÷ (Number of poles)
B^2L required equals:
for 6 poles = 1.5x(B^2L for 4 poles)
for 8 poles = 1.85x(B^2L for 4 poles)
for 10 poles = 2.70x(B^2L for 4 poles)

Table II—Values Taken From Rewound Motors for Checking Purposes

Hp.	Poles	Bore	Length	BxBxL
¼	4	3¼	2⅛	22.49
⅜	6	5	2¼	56.25
½	4	3⅝	2⅜	31.21
¾	4	4⅜	1⅝	31.10
1	4	4¼	2½	45.15
1	4	5¼	2	55.12
1	6	5	3	75.00
1	6	5⅞	2⅛	73.35
1	10	7	2¼	110.25
1½	6	5⅛	3⅛	82.08
2	4	6	2½	90.00
2	4	5	3	75.00
2	4	5¼	3¼	89.57
2	6	6	3	108.00
3	4	5⅝	3⅛	98.88
3	6	7	3⅛	153.13
5	4	6⅝	2⅞	126.18
5	4	7⅛	3	152.31
5	6	8	3⅜	216.00
5	8	9½	3¾	338.44
7½	6	8½	4⅜	316.09
7½	4	....	....	270.85

Table III—Cylindrical Inches Obtained from Bore and Length of Iron of Stator

Bore in Inches	(BxB) Bore Squared	Cylindrical Inches or (BxBxL)												
		*1.0	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00
2½	6.25	6.25	7.81	9.37	10.93	12.50	14.06	15.62	17.18	18.75	20.31	21.87	23.44	25.00
2⅝	6.89	6.89	8.62	10.32	12.05	13.78	15.50	17.21	18.94	20.67	22.40	24.12	25.82	27.56
2¾	7.66	7.66	9.58	11.33	13.41	15.32	17.24	18.99	20.91	22.98	24.90	26.82	28.57	30.65
2⅞	8.26	8.26	10.33	12.40	14.46	16.53	18.60	20.66	22.73	24.79	26.86	28.93	31.00	33.06
3	9.00	9.00	11.25	13.50	15.75	18.00	20.25	22.50	24.75	27.00	29.25	31.50	33.75	36.00
3⅛	9.76	9.76	12.20	14.65	17.09	19.53	21.96	24.41	26.85	29.29	31.73	34.16	36.61	39.06
3¼	10.56	10.56	13.20	15.85	18.49	21.12	23.76	26.41	29.05	31.70	34.32	36.96	39.61	42.25
3⅜	11.39	11.39	14.23	17.08	19.93	22.78	25.62	28.47	31.31	34.17	37.01	39.85	42.70	45.56
3½	12.25	12.25	15.32	18.38	21.43	24.50	27.57	30.63	33.70	36.75	39.82	42.89	45.95	49.00
3⅝	13.14	13.14	16.43	19.72	23.23	26.28	29.57	32.86	36.15	39.42	42.71	46.00	49.29	52.56
3¾	14.06	14.06	17.58	21.09	24.61	28.12	31.64	35.15	38.67	42.18	45.70	49.22	52.73	56.25
3⅞	15.01	15.01	18.77	22.52	26.27	30.03	33.79	37.53	41.29	45.05	48.80	52.56	56.32	60.06
4	16.00	16.00	20.00	24.00	28.00	32.00	36.00	40.00	44.00	48.00	52.00	56.00	60.00	64.00
4⅛	17.01	17.01	21.27	25.52	29.77	34.03	38.28	42.53	46.79	51.04	55.30	59.55	63.80	68.06
4¼	18.06	18.06	22.58	27.09	31.61	36.13	40.64	45.15	49.67	54.18	58.71	63.22	67.73	72.26
4⅜	19.14	19.14	23.93	28.71	33.49	38.28	43.17	47.85	52.64	57.42	62.21	67.10	71.88	76.56
4½	20.25	20.25	25.31	30.37	34.43	40.50	45.56	50.62	55.68	60.75	65.81	70.87	75.93	81.00
4⅝	21.39	21.39	26.74	32.08	37.42	42.78	48.13	53.47	58.82	64.17	69.52	74.87	80.21	85.56
4¾	22.56	22.56	28.20	33.84	39.48	45.12	50.76	56.40	62.04	67.68	73.32	78.96	84.50	90.24
4⅞	23.76	23.76	29.70	35.64	41.60	47.53	53.46	59.40	65.34	71.29	77.23	83.16	89.00	95.06
5	25.00	25.00	31.25	37.50	43.75	50.00	56.25	62.50	68.75	75.00	81.25	87.50	93.75	100.00
5⅛	26.26	26.26	32.83	39.40	45.96	52.53	59.10	65.66	72.23	78.79	85.38	91.93	98.50	105.06
5¼	27.56	27.56	34.45	41.35	48.23	55.12	61.90	68.91	75.80	82.69	89.57	96.35	103.25	110.25
5⅜	28.89	28.89	36.11	43.38	50.55	57.78	65.00	72.27	79.49	86.67	93.89	101.11	108.38	115.56
5½	30.25	30.25	37.81	45.38	52.93	60.50	68.06	75.63	83.19	90.75	98.31	105.87	113.44	121.00
5⅝	31.64	31.64	39.55	47.46	55.37	63.28	71.20	79.10	87.00	94.92	102.83	110.75	118.66	126.56
5¾	33.06	33.06	41.32	49.59	57.86	66.12	74.38	82.65	90.91	99.18	107.44	115.70	124.97	132.25
5⅞	34.51	34.51	43.14	51.77	60.40	69.03	77.65	86.28	94.91	103.54	112.17	120.79	129.42	138.06
6	36.00	36.00	45.00	54.00	63.00	72.00	81.00	90.00	99.00	108.00	117.00	126.00	135.00	144.00
6⅛	37.51	37.51	46.90	56.27	65.65	75.03	84.41	93.78	103.16	112.54	121.93	131.30	140.68	150.06
6¼	39.06	39.06	48.82	58.59	68.36	78.12	87.92	97.65	107.42	117.18	126.94	136.71	146.48	156.24
6⅜	40.64	40.64	50.80	60.95	71.12	81.28	91.44	101.59	111.76	121.92	132.08	142.23	152.40	162.56
6½	42.25	42.25	52.80	63.37	73.83	84.50	95.05	105.62	116.08	126.75	137.30	147.87	158.33	169.00
6⅝	43.89	43.89	54.86	65.83	76.80	87.78	98.75	109.72	120.69	131.67	142.64	153.61	164.58	175.56
6¾	45.55	45.55	56.94	68.32	79.71	91.10	102.49	113.87	125.26	136.65	148.04	159.42	170.83	182.20
6⅞	47.27	47.27	59.08	70.90	82.72	95.54	106.35	118.17	130.00	141.81	154.62	165.44	178.26	191.08
7	49.00	49.00	61.25	73.50	85.75	98.00	110.25	122.50	134.75	147.00	159.25	171.50	183.75	196.00
7⅛	50.77	50.77	63.46	76.15	88.85	101.54	114.23	126.92	139.62	152.31	165.00	177.69	190.39	203.08
7¼	52.56	52.56	65.70	78.84	92.00	105.12	118.26	131.40	144.56	157.68	170.82	183.96	197.12	210.24
7⅜	54.39	54.39	67.98	81.58	95.18	108.78	122.37	135.97	149.57	163.17	176.76	190.36	203.96	217.56
7½	56.25	56.25	70.31	84.37	98.44	112.50	126.56	140.62	154.69	168.75	182.81	197.87	210.94	225.00
7⅝	58.14	58.14	72.67	87.20	101.75	116.28	130.81	145.34	159.89	174.42	188.95	203.48	218.03	232.56
7¾	60.06	60.06	75.07	90.09	105.10	120.12	135.13	150.15	165.16	180.18	195.19	210.21	225.22	240.24
7⅞	62.02	62.02	77.52	93.03	108.53	124.04	139.54	155.05	170.55	186.06	201.56	217.07	232.57	248.08
8	64.00	64.00	80.00	96.00	112.00	128.00	144.00	160.00	176.00	192.00	208.00	224.00	240.00	256.00
8⅛	66.02	66.02	82.52	99.03	115.53	132.04	148.54	165.05	182.55	198.06	214.56	231.07	247.57	264.08
8¼	68.06	68.06	85.07	102.09	119.11	136.12	153.13	170.15	187.17	204.18	221.19	238.21	255.23	272.24
8⅜	70.14	70.14	87.67	105.21	123.77	140.28	158.81	176.35	193.91	210.42	227.95	247.49	263.05	280.56
8½	72.25	72.25	90.31	108.37	126.44	144.50	162.56	181.62	198.69	216.75	234.81	253.87	270.94	289.00
8⅝	74.39	74.39	92.98	111.58	130.18	148.78	167.37	185.97	204.57	223.17	241.76	260.36	278.96	297.56
8¾	76.56	76.56	95.70	114.84	134.00	153.12	172.26	191.40	210.56	229.68	248.82	267.96	287.12	306.24
8⅞	78.77	78.77	98.46	118.15	137.85	157.54	177.23	196.92	216.62	236.31	256.00	275.69	295.39	315.08
9	81.00	81.00	101.25	121.50	141.75	162.00	182.25	202.50	222.75	243.00	263.25	283.50	303.75	324.00
9⅛	83.12	83.12	103.90	124.68	145.46	166.24	187.02	207.80	228.58	249.36	270.14	290.92	312.70	332.48
9¼	85.56	85.56	106.95	128.34	149.73	171.12	192.51	213.90	235.29	256.68	278.07	299.46	320.85	342.24
9⅜	87.89	87.89	109.86	131.83	153.81	175.78	197.75	219.72	241.70	263.67	285.64	307.61	339.59	351.56
9½	90.25	90.25	112.81	135.37	157.94	180.50	203.06	225.62	248.20	270.75	293.31	315.87	338.44	361.00

*Values given in this line are lengths of core in inches.

[1 and 1 + (12 × .80)] or (1 and 1 + 9.6), which is 1-and-10.

For a two-phase motor, the turns per phase with a series connection will be:

$T = (E \times 100{,}000{,}000) \div (4 \times \Phi \times F)$, where E equals the line voltage, Φ the flux per pole, and F the frequency. Then the turns per coil equal T divided by the coils per phase.

For three-phase, the turns per phase for a series-delta connection will be:

$T = (E \times 100{,}000{,}000) \div (4.25 \times \Phi \times F)$. For a series-star connection, the turns per phase become $(E \times 100{,}000{,}000) \div (7.35 \times \Phi \times F)$.

A series-star connection requires less turns of a larger wire, and a series-delta connection a greater number of turns of a smaller wire. The majority of motors are star-connected. So the safe procedure is to figure out the turns for a series-star connection and then if the wire is too large try a series-delta connection.

We will next work out one or two examples: First, take the stator having a 6-in bore and 2½-in. length of iron. This motor is good for 3 hp. at 1,800 r.p.m. When it is to be operated three-phase, 220 volts, 60 cycles, the flux per pole equals (0.636 × 4.712 × 2.4 × 25,000) or 187,250 lines. Then for a series-star connection, T per phase equals (220 × 100,000,000) ÷ (7.35 × 187,250 × 60) equals 266 turns. As this stator has forty-eight slots, we will use a two-layer, diamond-shape mush coil. There will be forty-eight coils, or 48 ÷ 3 equals 16 coils per phase. Then the turns per coil equal 266 ÷ 16, equals 16.6 or sixteen turns will be close enough.

By the table on page 232, a 3-hp. 220-volt, four-pole motor will take 8.1 amp. From Table I we find that a 3-hp. motor requires 600 circ. mil per ampere. This size of wire in circ. mil equals 8.1 × 600 equals 4,860 circ. mils. Then from wire Table V we find the nearest size is No. 14 with 4,107 circ. mil or No. 13 with 5,178. No. 14 will do, but if there is enough room in the slot for No. 13 it would make a more efficient motor.

The best method of determining whether an estimated size of wire can be wound is to insulate one slot; then cut up small lengths of wire of the gage size figured and fill the slot with the required number of turns. In this case we would try 2 × 16 equals 32, No. 14 double-cotton-covered wires.

When the size of wire required is above No. 15 and it is desired to make a mush coil, the better procedure would be to double the turns, halve the size of wire and use a parallel connection. This makes a coil that is easier to handle and shape. In this case we could use thirty-two turns of one No. 17 wire per coil and connect for two-parallel star.

When a delta connection is used the amperes per terminal, as given in table, page 232, must be divided by 1.73 to get the amperes per phase. Or in the case just figured, 8.1 ÷ 1.73 equals 4.624 amp. Then the circ. mil required equals 4.624 × 600 equals 2,774.4, or a No. 16 wire will do.

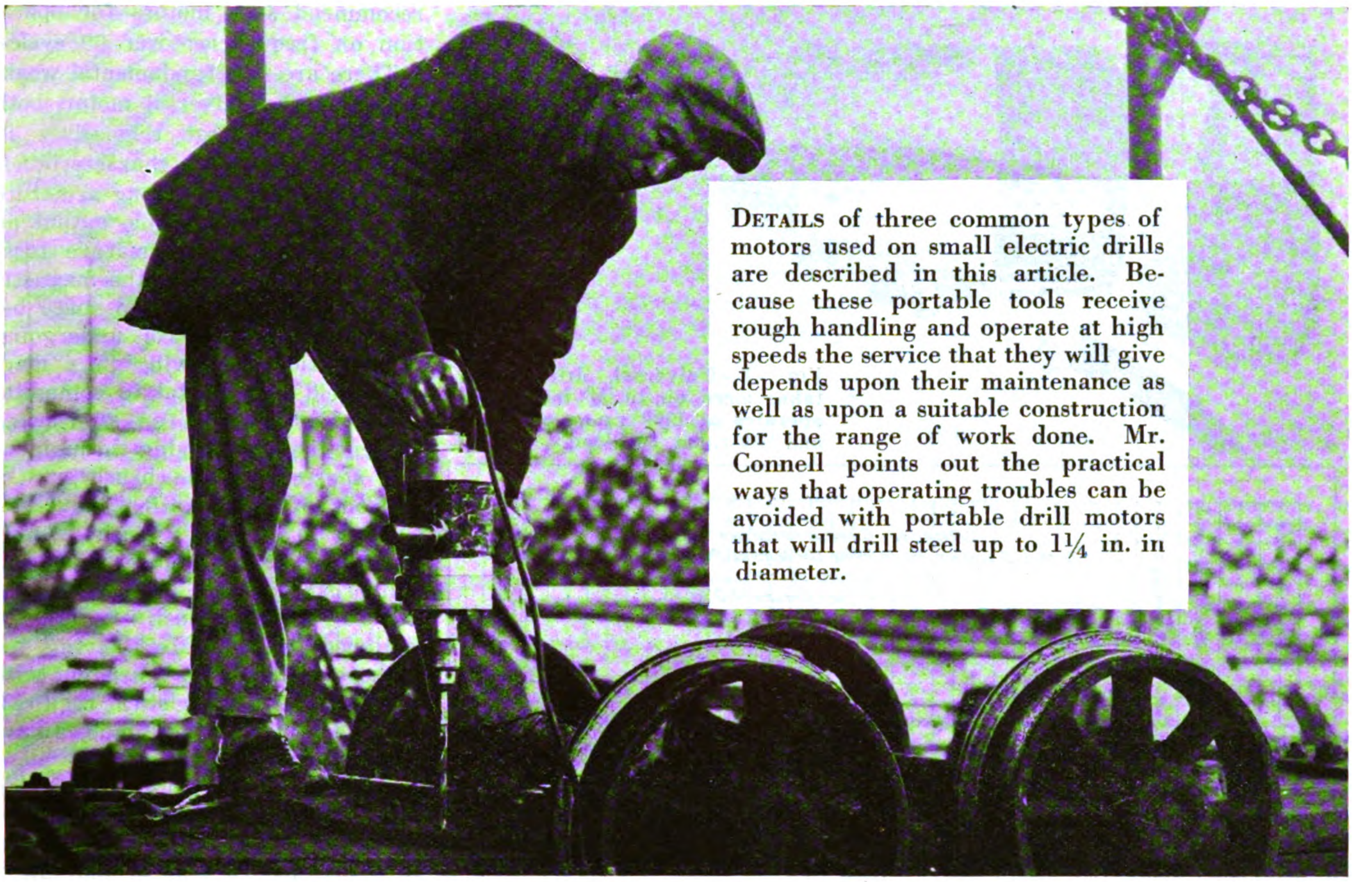
Another and better method of figuring the size of wire in circ. mil for a delta connection is to take the value given (*Continued on page 258*)

Table IV—Values of Pole Pitch for Different Bores and Poles

Bore in Inches	Bore Times 3.14	S_1 = Pole Pitch in Inches		
		2-Pole	4-Pole	6-Pole
2½	7.85	3.975	1.987	1.325
2⅝	8.25	4.125	2.062	1.375
2¾	8.64	4.320	2.160	1.440
2⅞	9.03	4.515	2.257	1.505
3	9.42	4.710	2.355	1.570
3⅛	9.82	4.910	2.455	1.636
3¼	10.21	5.105	2.552	1.701
3⅜	10.60	5.300	2.650	1.767
3½	10.99	5.495	2.747	1.831
3⅝	11.39	5.695	2.847	1.898
3¾	11.78	5.890	2.945	1.963
3⅞	12.17	6.085	3.042	2.028
4	12.57	6.285	3.142	2.095
4⅛	12.96	6.480	3.240	2.160
4¼	13.35	6.675	3.337	2.225
4⅜	13.74	6.870	3.435	2.290
4½	14.14	7.070	3.535	2.356
4⅝	14.53	7.265	3.632	2.421
4¾	14.92	7.460	3.730	2.486
4⅞	15.32	7.660	3.830	2.553
5	15.71	7.855	3.927	2.618
5⅛	16.10	8.050	4.025	2.683
5¼	16.49	8.245	4.122	2.748
5⅜	16.89	8.495	4.247	2.835
5½	17.28	8.640	4.320	2.880
5⅝	17.67	8.835	4.417	2.945
5¾	18.06	9.030	4.515	3.010
5⅞	18.46	9.230	4.615	3.076
6	18.85	9.425	4.712	3.141
6⅛	19.24	9.620	4.810	3.206
6¼	19.64	9.820	4.910	3.273
6⅜	20.03	10.015	5.007	3.338
6½	20.42	10.210	5.105	3.403
6⅝	20.81	10.405	5.202	3.468
6¾	21.21	10.605	5.302	3.535
6⅞	21.60	10.800	5.400	3.600
7	21.99	10.995	5.497	3.665
7⅛	22.38	11.190	5.595	3.730
7¼	22.78	11.390	5.695	3.796
7⅜	23.17	11.585	5.792	3.861
7½	23.56	11.780	5.890	3.926
7⅝	23.95	11.975	5.987	3.992
7¾	24.35	12.175	6.087	4.058
7⅞	24.74	12.370	6.185	4.123
8	25.13	12.565	6.282	4.188
8⅛	25.53	12.765	6.382	4.255
8¼	25.92	12.960	6.480	4.320
8⅜	26.31	13.155	6.657	4.385
8½	26.70	13.350	6.675	4.450
8⅝	27.10	13.550	6.775	4.516
8¾	27.49	13.745	6.872	4.581
8⅞	27.88	13.940	6.970	4.646
9	28.27	14.135	7.067	4.711
9⅛	28.67	14.385	7.192	4.795
9¼	29.06	14.530	7.265	4.843
9⅜	29.45	14.725	7.362	4.908
9½	29.85	14.925	7.462	4.975

Table V—Dimensions of Bare, Double-Cotton-Covered and Single-Cotton-Covered-and-Enameled Wire

Size B & S Gauge	Diameter in Inches			Area	
	Bare	D. C. C.	S. C. & En.	Sq. In.	Circ. Mil
1	.2893	.3073	....	.06753	83690
2	.2576	.2756	....	.05213	66370
3	.2294	.2474	....	.04134	52630
4	.2043	.2223	....	.03278	41740
5	.1819	.1999	....	.02600	33100
6	.1620	.1780	....	.02062	26250
7	.1443	.1603	....	.01635	20820
8	.1285	.1425	....	.01297	16510
9	.1144	.1264	....	.01028	13090
10	.1019	.1119	....	.00815	10380
11	.0907	.1007	....	.00647	8234
12	.0808	.0908	.0875	.00513	6530
13	.0720	.0820	.0787	.00407	5178
14	.0641	.0731	.0707	.00323	4107
15	.0571	.0661	.0637	.00256	3257
16	.0508	.0598	.0573	.00203	2583
17	.0452	.0542	.0516	.00161	2048
18	.0403	.0493	.0467	.00128	1624
19	.0359	.0449	.0123	.00101	1288
20	.0320	.0410	.0382	.00080	1022
21	.0285	.0375	.0346	.00064	810.1
22	.0253	.0343	.0315	.00050	642.4
23	.0226	.0316	.0286	.00040	509.5
24	.0201	.0291	.0262	.00032	404.0
25	.0179	.0269	.0239	.00025	320.4
26	.0159	.0249	.0219	.000199	254.1
27	.0142	.0232	.0201	.000158	201.5
28	.0126	.0216	.0185	.000125	159.8
29	.0113	.0203	.0170	.0000995	126.7
30	.0100	.0190	.0158	.0000789	100.5



DETAILS of three common types of motors used on small electric drills are described in this article. Because these portable tools receive rough handling and operate at high speeds the service that they will give depends upon their maintenance as well as upon a suitable construction for the range of work done. Mr. Connell points out the practical ways that operating troubles can be avoided with portable drill motors that will drill steel up to $1\frac{1}{4}$ in. in diameter.

Some Practical Pointers on the

Performance of Small Portable Drill Motors

With Details of Brushes Required—Connections of Windings for Correct Polarity and Direction of Armature Rotation

By EDWIN L. CONNELL

Chief Engineer, Van Dorn Electric Tool Company, Cleveland, Ohio

THE WORD "universal" as applied to an electric motor is a short way of saying that the motor is designed to operate on either direct or alternating current of a specified voltage.

There are two very important reasons for using such a motor in an electric drill. First, a portable machine of such general utility should run from the most convenient source of power at the point of use. This is, of course, the lamp socket. And second, portable drilling machines must be equipped with a varying speed motor that develops its maximum torque at standstill.

The portable drill is called upon to drill in all kinds of material with bits varying within and, all too frequently, beyond the capacity of its chuck or socket. Hard spots in the material and oversize work require increased torque at reduced speeds, thus preventing stalling, breaking of bits and providing a working speed that more or less automatically adjusts itself to the size of the bit. These are the characteristics of the series direct-current motor and the series, alternating-current commutator motor. The "universal" motor is a series or alternating-current, commutator motor with no features that prevent its operation on direct current.

The simplest type of universal motor differs from the direct-current series motor in details only. It consists of an armature that is identical in construction with all direct-current armatures, connected in series with field coils mounted on a laminated core. The lamination of the complete magnetic path is necessary to eliminate destructive heating in the iron when carrying an alternating-current magnetic flux. The ratio of the ampere turns in the field to the ampere turns in the armature will be lower in this type of motor than is considered good practice in direct-current motors. Fig. 4 shows the ordinary field assembly of this simple type.

The performance characteristics of such a motor are shown in Fig. 2. It will be observed that the problem of power factor enters when this motor is operated on alternating current. The reactance of the windings causes the current to lag behind the impressed voltage and the power produced is correspondingly less than is produced on direct current at the same ampere input. The output for a given ampere input and the maximum output will always be less on a. c. than on d. c. and there will be a very great difference in a poorly designed motor. The maximum output is always lower on the higher frequencies, which explains why most manufacturers do not

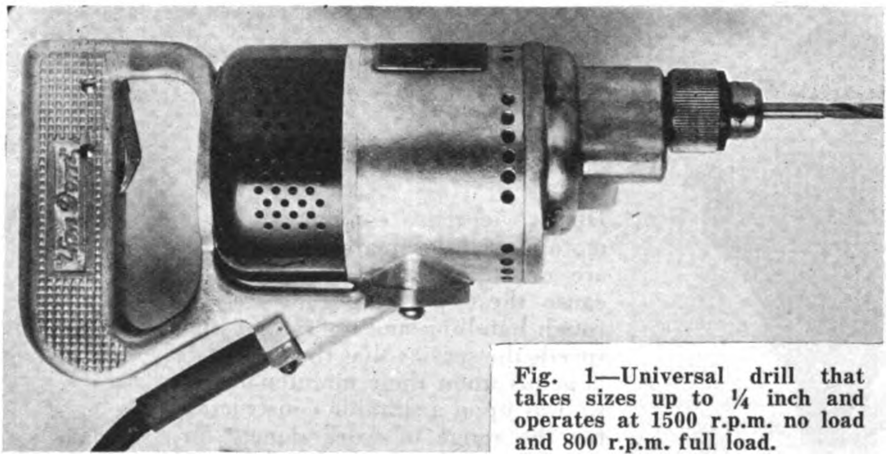
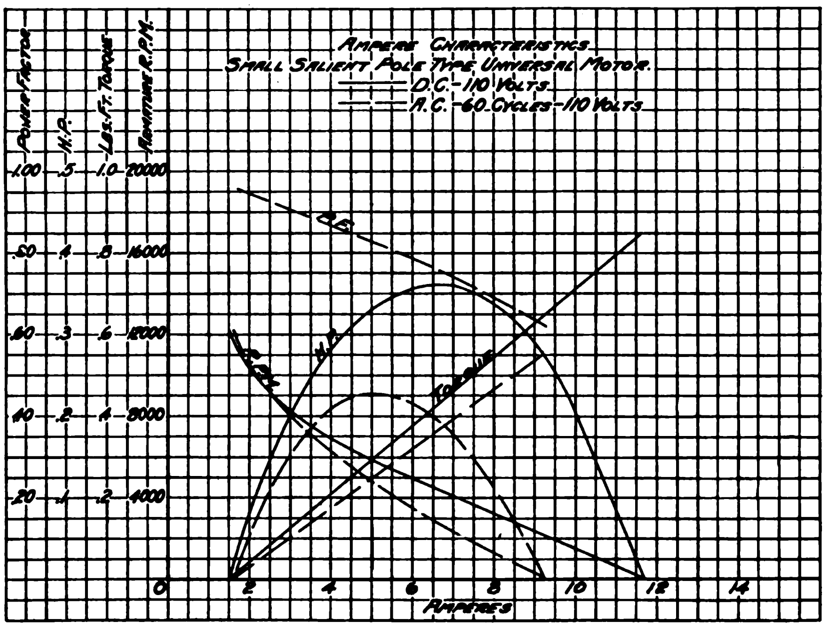


Fig. 1—Universal drill that takes sizes up to ¼ inch and operates at 1500 r.p.m. no load and 800 r.p.m. full load.



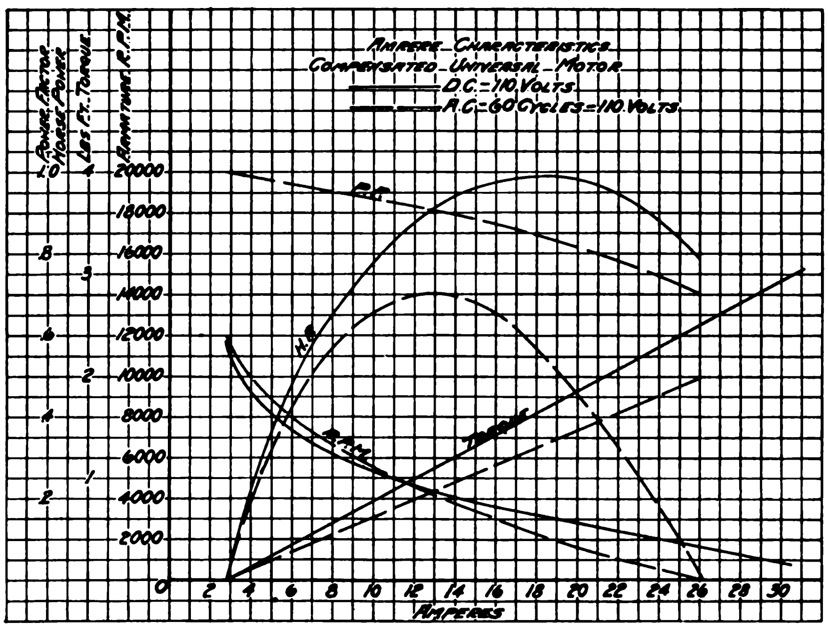


Fig. 2—Performance curves (top illustration) for a small salient pole type universal motor.
Note that power factor enters when the motor is operated on alternating current and that the power produced is less than it is in d.c. operation.

Fig. 3—Performance curves for a universal motor of moderate size with compensated field winding.
In the larger sizes this type of motor is a serviceable design, but the no-load speed should be kept reasonably low to prevent self-destruction.

recommend such motors for operation on frequencies over 60 cycles.

There are two fundamental weaknesses in the universal motor, both of which manifest themselves in poor commutating characteristics. The weak field and strong armature necessary for a tolerable output on a. c. produce high armature reaction. In other words, the magnetic field is deflected into the space between poles and the coil undergoing commutation is moving in a magnetic field detrimental to commutation. Furthermore, on alternating current the field passing through the coil shorted by the brush at the moment of commutation induces a current in the coil which is only limited by the resistance of the coil and brush contact. It is, therefore, imperative that such motors be equipped with brushes having the highest contact drop consistent with the other characteristics required. Manufacturers of these motors have made extensive tests and they alone should be trusted in specifying proper brushes. Improper brushes may lead to short life of the armature because they have too low a contact drop, because they are too hard, or because they are not abrasive enough to prevent high mica. Extreme hardness is likely to accompany extremely high contact drop and too much abrasive action produces destructive commutator wear. A brush that has a shunt connection is always worth the extra cost.

Universal Motor with Field Winding Distributed in Slots

The second type of universal motor is built with a field winding distributed in slots, usually in concentric groups corresponding to the number of poles. The brushes are displaced against rotation from the neutral position so that part of the winding acts as a compensating winding. The armature reaction is thereby neutralized or reduced appreciably and the elimination of a large part of this armature flux reduces the reactance of the armature and improves the power factor. However, there will always be a field detrimental to commutation in the path of the coil undergoing commutation and since a distributed field winding to produce a given magneto-motive force has a higher impedance than the equivalent single coil, a very small motor of this construction may be inferior to a well-designed one of the salient-pole type.

The brush position with this dis-

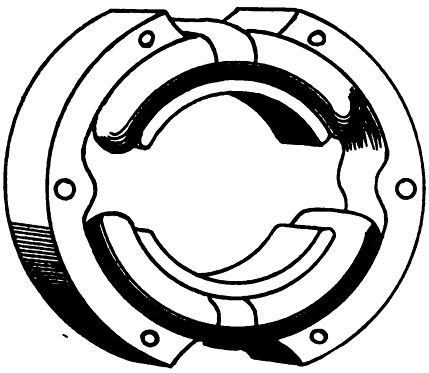


Fig. 4—An ordinary field assembly for a universal motor.

tributed field winding is very important and when adjustable should be carefully marked before disturbing it for repairs.

This winding will usually be made by the skein method described by A. C. Roe in his article on "Winding Split-Phase Motors" in the May, 1922, issue of INDUSTRIAL ENGINEER. In the smaller sizes with six or eight slots per pole the skein will have the full number of turns per slot. The larger sizes may be wound more easily with a skein of half the required turns, or a split skein. As such motors are usually bipolar there will be two such coils, each distributed in half the number of slots. They should be connected in series to give opposite polarity. To check this polarity, connect the terminals to a source of direct current with a resistance in series to limit the current to a reasonable value and move a small compass around the outside of the coil ends. The needle should reverse when moved from pole to pole. The general rule is to connect the outside end of one pole to the outside of the other or its equivalent. Very often these two ends are not actually connected together but are connected to the brushes, thus completing the circuit through the armature.

UNIVERSAL MOTOR WITH MAIN AND COMPENSATING FIELD WINDINGS

The third type of universal motor, the most practical in the larger sizes, has the distributed field winding but does not depend upon the same coils for both main and compensating fields. The two sets of coils are placed in the slots independently in a manner very similar to the winding of a split-phase induction stator. The connection of these two windings is as shown in Fig. 5 for the direction of rotation indicated. The polarity of the compensating winding must be reversed with reversed rotation.

Such a winding provides full compensation for armature reaction and excellent power factor and although quite satisfactory in sizes entirely impossible with the other windings, the short-circuit current is still present and is the real obstacle in the way of its complete success in still larger sizes. Fortunately, however, the limit is beyond all reasonable power requirements for drilling in steel up to 1¼ in. in diameter. The performance characteristics of a motor of moderate size with this compensated field winding are shown in Fig. 3.

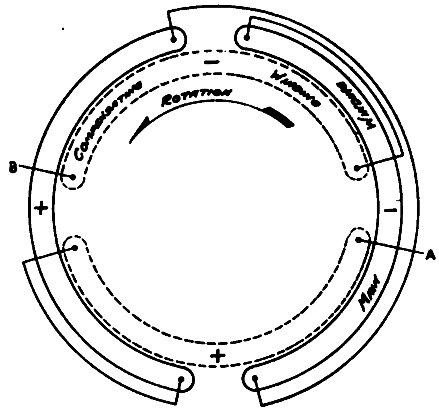


Fig. 5—Connections for main winding and compensating field winding for a universal motor.

The compensating winding provides for armature reaction and power factor.

The universal motor is inherently a high-speed motor and there is great temptation to resort to extreme speeds to obtain the extra power or light weight. Since these motors have series characteristics, the no-load speed is much higher than the working speed and should be always kept within reasonable limits.

Of course, quality of construction has a great influence on the permissible speeds, but with every-day, knock-about use and practical methods of maintenance, the highest speed motors are likely to prove self-destructive. The universal drills on the market today will be found to have armature speeds within the range of 10,000 r.p.m. to 20,000 r.p.m. The lower figure would be considered ultra-conservative in a small machine and the higher figure beyond the practical limit for the smallest portable drill.

The average drill of ¼-in. capacity will develop a maximum output on 60 cycles of 1/20 to 1/10 hp. The light-weight, ½-in. capacity drills will develop a maximum of 1/6 to ¼ hp. The heavier type ½-in. drills will average about 1/3 hp. and the still larger sizes show a wide range from ½ hp. up.

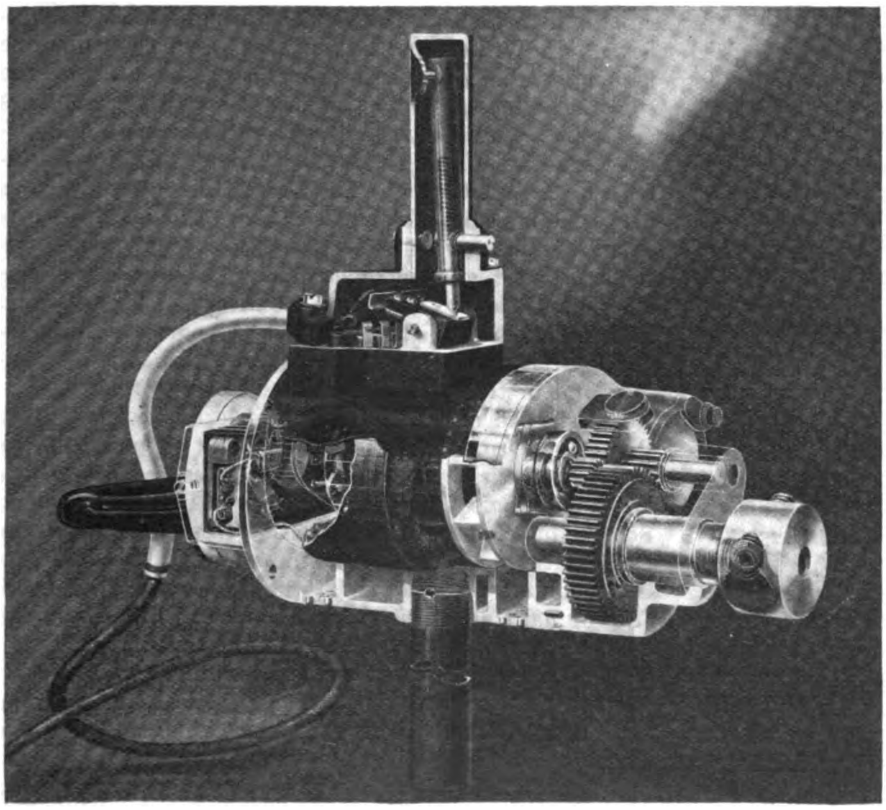


Fig. 6—Construction of a portable drill adapted for all around hard service that operates from 700 to 300 r.p.m.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT F. E GOODING A. J. WHITCOMB

Chicago, May, 1924

Plans Work Because They're Worked

AN ENGINEER in writing to us about a new graphical plan for controlling maintenance, which we hope to tell you more about later, said: "It works, but I have to make it work." That in a nutshell is a good definition of the major portion of a maintenance engineer's job. Often his task is to make some machine function more reliably or with less upkeep expense, or a combination of both. The machine may work after a fashion, but not in the manner that it should. In such cases "making it work" is accomplished by the solution of a series of problems.

For instance, in this issue is described a case of bearing trouble in which the bearing sleeves had an average life of six weeks. A variety of bearings and lubrication schemes were tried but all failed. This was through no fault of their own but simply because of the severe service and load conditions to which the bearings were subjected and were not designed to meet. The engineer in charge of operation and maintenance had to make this drive work. The ingenuity he displayed in solving this problem by applying ball bearings and protecting them with a housing sealed with stuffing boxes, gives an insight into the general makeup of the live-wire maintenance methods he used in making a particular installation an efficient productive unit of the works organization.

Ford Plants Save Everything

JUST what good, old-fashioned thrift means around a large industrial works is vividly illustrated by the work of the general salvage department in the Ford automobile plants. The salvage squads of this department hunt around for everything that is not used and generally termed scrap materials. They not only collect this material, but make repairs, remake and dispose of their collections at a return therefrom that runs into the astounding figure of nearly a million dollars per month.

Nothing is too small to handle. They take anything from a broken mop pail to a discarded factory building. The extent of the work is indicated by the salvage department's records, which show that about 400 tons of steel trimmings are disposed of every day, while 200 tons of baled steel stampings and waste, and 150 tons of cast-iron borings are gathered up and converted into usable material. Other items in the daily clean-up include about 10 tons of waste paper, 3 tons of factory sweepings, 2 to 8 tons of baled tin, hoops and wire, etc. About $1,000 worth of belting is reclaimed every day for use again or made up into leather aprons, mitts, and hand pads, or into gaskets and cup washers for pumps and the like. Repairs to broken tools run into a saving of nearly $700 per day and something like 2,000 gallons of oil per day are returned for reuse from passing steel turnings through centrifugal wringers.

These are only a few of the salvage items, but they are enough to indicate the need of good housekeeping in a modern works where things are bought and used in large quantities by those whose job it is to make and assemble many small parts into a machine.

Another interesting feature about this work is that it gives employment to men with ill health, those who have been crippled and others whose age may have reduced their productive ability on other work. More than 400 such men are so employed in the Ford works. Here then are two things to think about; the revenue from salvage and a way of taking care of loyal employes on a basis that permits them to earn a wage and not feel that they are an object of charity.

Lighting From Windows

SOMEONE has said that the most common thing about common-sense is that it is rather uncommon. The same might be said about good lighting in mills and factories, in daytime, through side wall windows. In Winter and Springtime when the sunshine is bright, the glare bothersome and the heat of the sun's rays uncomfortable, shades are drawn or shutters and blinds are partially closed, reducing both ventilation and the lighting. With daylight varying in intensity from different windows on the different sides of a building and the shades drawn on one side in the morning and up on the other and *vice versa* in the afternoon, work is being done under varying intensities throughout the day and with the direction of maximum intensity varying. Discomfort and poor work is frequently the result, which is charged to the heat of summer time or the ventilation of the working room.

About good daylight lighting little has been written that is of as much practical value to a shopman as the information in an extensive paper presented before the last annual meeting of the Illuminating Engineering Society by H. H. Higbie and G. W. Younglove of the University of Michigan at Ann Arbor, Mich. The authors pointed out that about the only guide in the design of natural lighting from windows is a few rough rules-of-thumb, such as included in the Society's Revised Code of Lighting School Buildings: namely, "It is recommended that the room be so designed that no work space is more distant from the window than twice the height of the top of the window from the floor" and that "tests of daylight in a well lighted school building

indicate that in general the window glass area does not fall below 20 per cent of the floor area. As the upper part of the window is more effective in lighting the interior than the lower part, it is recommended that the top of the glass be no greater distance than 12 in. below the ceiling."

Since many factories present working conditions similar to the school room with lighting in daytime entirely from side windows, these thumb rules are of interest, but there is a total lack of test data and recommendations on how to make the best use of daylight after the building is designed and different operations are being conducted therein that call for good lighting in daylight hours.

Much information is available on artificial lighting and good practical use has been made of it but in Spring, Summer and Fall the longest working hours, except on dark days, are with natural lighting. And in some cases where there is an excellent lighting arrangement when using electric light, workmen on bright days are literally in the dark.

We need more information that will help mills and factories to make the best use of shades, reflectors and deflectors of sunlight; more information on the best kinds of window glass, window sashes, paints and wall surfaces to make the best use under existing working conditions of daylight, the light source that costs us nothing and of which the supply is unlimited.

In this issue an article appears that deals with the use of paint to improve reflecting surfaces under both daylight and artificial lighting. We hope that some of our readers will assist us further in the discussion of this subject by reporting any investigations they have made along the lines of the practical information to which attention is called here.

Don't Cut The Pattern To Fit the Goods

IN THE following words a power transmission engineer recently called attention to an oversight that is undoubtedly often made: "Many plants could, when they are putting up new buildings or making additions thereto, save a good deal of bother and expense if proper provision were made at the time the building is erected for putting up shafting, pipe lines, conduit and so on." By way of explanation he pointed out that in many instances the plans drawn by the architect or designing engineer cover only the building proper. When the conduit, water, gas, steam and other lines are installed the foreman of each gang lays out and does his part of the work according to his own notions. Usually he runs his lines in what is, for him, the easiest and most convenient way, without regard for other equipment.

The result is that when the power transmission engineer comes in to do his work he is forced to use all sorts of expedients in order to get room to place the line- and countershafting, pulleys and so on where they should go. Oftentimes it is necessary to put in a good deal of expensive ground-work, which would not be needed if more foresight had been exercised and the work of the various departments properly co-ordinated.

The best time to make provision for supporting shaft-hangers and similar equipment is when the building is being erected. In any event, the installation of such equipment should be given early attention, for the reason that lines of shafting can not be so readily adapted to fit conditions as can conduit and other pipe lines. The latter can, when necessary, be run around obstacles without much difficulty. This is not true, however, of shafting. Consequently, when making new installations, or rearranging old ones, time and expense will be saved by putting up the shafting first and running the pipe lines around it, rather than by trying to make the shafting dodge something that can be more easily changed.

One Chief and Capable Assistants

SEVERAL interesting letters have been received commenting on the organization of operating and maintenance work in industrial works as outlined by readers in the February issue of INDUSTRIAL ENGINEER. The following excerpt is from a letter that carries proof of the point brought out as well as conviction:

> It has been my experience as an electrical engineer that a plant can be operated more economically and with minimum friction between employees if the plant is under one head. There is an enormous waste of energy in many plants today, due to jealousy and friction in the various departments when they are under different heads. When a plant is 100 per cent electrified, either by purchased power or power generated locally, the electrical engineer should be fully qualified to take charge of the plant from the boiler room to the finished product.
>
> For instance, in the cement industry, with which I am connected at present, I was recently called into one plant where there was a low power factor and an excessive energy cost in kilowatt-hours per barrel. I found that several motors from 112 hp. to 250 hp. were operating twenty-four hours per day, while with proper management the same amount of material could be produced in a ten-hour day. This plant was divided into different departments with a master mechanic, general foreman and foreman in charge. Under this form of operation I could not get the desired results until I finally placed the proposition before the management and secured entire charge of all departments. From then on it was impossible for the various foremen to pass the buck one to the other and we actually accomplished in ten hours what formerly had required twenty-four hours.
>
> I worked with my men throughout the plant paying special attention to shaft alignment, bearings, the grinding conditions of various mills, watching the attendants operating the mills at their maximum load, with the result that we increased the power factor of motor operation with an induction load from 78 to 90 per cent with no power factor correction machinery. This reduced the kilowatt-hours per barrel of cement produced, increased the total output and decreased the mill-hours run.
>
> The point I wish to make in this connection is, that to obtain economy and efficiency in the average plant the engineer in charge should familiarize himself with production details and specialize in the operating details of the industry he is engaged in to make sure that he is eliminating all wasteful energy. From my experience in various plants I cannot conceive of a better method of elevating the position and responsibility of electrical and mechanical engineers than to take this stand if they desire to make a success of their profession.

In general, "what's everybody's business is nobody's business," so that if we were forced to take sides on this matter of operating responsibility, we would favor that organization lineup which calls for one general supervising head who is the last word in operating methods and procedure with capable assistants in charge of the main divisions of work, as outlined in the organization diagram that appeared on page 14 of the January, 1924, issue. The titles of assistants to the chief matter little; it's the responsibility that counts, but suitable titles are suggested in that diagram.

Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Transformer for Testing Three-Phase Motors—Will some of your readers tell me if it is possible to build a step-up transformer, from 220 to 550 volts, with open cores? I want a transformer of about 5-kw. capacity that we could build in our shop, for testing three-phase motors. The efficiency of the transformer need not be taken into consideration in the design.
West Lynn, Mass. L. B. A.

• • • •

How Many Coils Can One Man Install in a Day?—I should like to have the opinion of readers of INDUSTRIAL ENGINEER on the following question: About how many coils installed in Westinghouse type CCL, three-phase, semi-closed slot stators of 75- to 90-hp. rating would be considered a good day's work for one man. Assume that he works eight hours a day and that all coils are taped at both ends, with the phase coils double-taped. Your comments will be much appreciated.
Douglas, Ariz. R. B. M.

• • • •

Lining Up Gears and Pinions—I would like to know some of the methods that readers of INDUSTRIAL ENGINEER use in lining up spur and bevel gears. How can I tell whether the gears and pinions are meshing too deeply or not deeply enough? I know how it should be done theoretically, but I would also like to know how it is done practically, out on the job.
Youngstown, Ohio. H. H.

• • • •

Trouble with Single-Phase Motor—I have a 1/3-hp., 110-volt, 60-cycle, single-phase induction motor of the split-phase starting type, having its windings on the rotor and the squirrel cage on the stator. This motor recently showed evidence of heating when running on light load and finally refused to start, even without load. On testing the windings, they were found to be free from opens, shorts and grounds. The centrifugal switch functions all right but shows burning at the contact points. The bearings were renewed and the contact points cleaned, after which the motor started on no-load when first reassembled, but after that it again refused to run. The rotor was free in the bearings and did not rub on the stator, also the brushes were operating all right. Will someone suggest what may be the cause of the trouble?
Newark, N. J. H. M.

• • • •

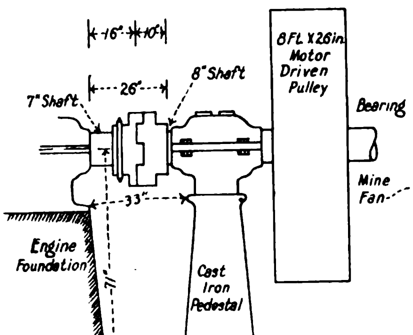
Why Does This Watt-Hour Meter Run Backwards?—I have a 150-kw. motor-generator set driven by a synchronous motor which is operated from a 2,200-volt line. When the set is started why does the watt-hour meter run backwards? The fact that it does run backwards surely does not mean that no power is used in starting. (2) When this machine is running at no-load should the ammeter on the exciter be adjusted so that the watt-hour meter runs very slowly, or so that it stands still? (3) When the watt-hour meter runs backwards, as mentioned, what is the cause of the trouble and what will be the effect? Will it harm the machine in any way? I shall appreciate any information which your readers can give me on these points.
Beaverdale, Pa. M. A. L.

• • • •

Rewinding 6-Volt Motor for 110 Volts—I have a Gray & Davis 6-volt d.c. motor which I would like to convert into an electric drill to operate on a single-phase, 110-volt, 60-cycle circuit. Is it possible to rewind this motor? It is equipped with a brush rocker and brush spacing device.
Logansport, Ind. L. E. G.

• • • •

What Kind of Clutch Should Be Used Here?—I should like to get your opinion on a clutch to be used for driving a mine fan. The sketch shows what we have at present, but it is not very satisfactory, due to the flywheel effect of fan and pulley, which causes excessive wear on the square-jaw clutch and results in back-lash at every stroke of the engine.



The engine is rated at 250 hp. at 175 r.p.m. and operates at full capacity, in one direction only. The clutch is used so that the engine may be thrown out part of the time and the fan driven by a 250-hp. motor belted to the pulley.

What type of clutch could I get that would fit into these dimensions and be able to carry the load?
Bicknell, Ind. H. S. B.

• • • •

Air Filter for Intake of Air Compressor—I should like to get a little information from someone who may be inclined to lend a helping hand. The plant where I am employed has installed two feather-valve air compressors. These compressors are subjected to coal dust, coal smoke and sand and we are having trouble with the valves. After cleaning them they operate satisfactorily for about 24 hours, and then begin to hang and stick.

Will someone please give me complete details of a suitable screen or air filter that I could make and use on the intake of these compressors?
Norfolk, Va. W. B. E.

Answers Received To Questions Asked

Winding Data for Type KT-4, General Electric Motor—Will some of the readers of INDUSTRIAL ENGINEER kindly tell me the proper winding for a type KT-4, form C, General Electric motor, No. 678120, 3 hp., 1,800 r.p.m., 220 volts, 60 cycles? What size wire should be used and how should the coils be connected? I wish to have this motor operate on 50 cycles. Should any change be made in the original winding?
Pasadena, Calif. H. B. S.

Referring to the question by H. B. S. in the March issue of INDUSTRIAL ENGINEER, the 220-volt, 60-cycle data for a type KT-4, Form C, three-phase, 1,800 r.p.m. motor is: thirty-six coils of thirty-four turns of one No. 17 single-cotton-and-enameled wire. The pitch should be 1-and-7 and the coils connected 2-parallel-star.

For 50 cycles, 220 volts, the coils should be wound with forty-one turns of one No. 18 silk-covered-and-enameled wire. The pitch should be 1-and-7 and the coils connected 2-parallel-star. The new rating would be 2½ hp., at 1,500 r.p.m.
Detroit, Mich. A. C. ROE.

• • • •

Removing Flange Couplings from Lineshafting—In the rearrangement of a group of machines, it was necessary to remove some solid pulleys from a lineshaft and replace them with others. This necessitated removing and replacing the flange couplings. We were not able to replace them so that they would run true and had to turn them down. I would like to know how other readers remove and replace flange couplings on lineshafts.
North Chicago, Ill. G. F. H.

Answering the question asked by G. F. H. in the April issue, possibly the trouble which appears to be in the coupling is really in the shaft; it may be out of line or level.

If the flanges had been prick-punched before removal they would likely go together properly; in fact, they may have been so marked on their edges, but the marks were not found. I would recommend a good cleaning of the coupling and a close search for file cuts or punch marks before any turning down is done.

Then again, if it is impossible to line up the two parts of a coupling exactly they could be separated anywhere from ½ in. to 1 in., leather discs inserted between them and then bolted tightly together, if the load is not too heavy. A

coupling altered in this way will be more or less flexible. If the shaft is traveling fast, say over 150 r.p.m., it would be safer to place a hanger on each side of the coupling so that in case the leather should tear apart the shaft ends, being very short, could not bend at right angles and whip around, due to centrifugal force.

New Britain, Conn. H. S. RICH.

* * * *

Portable Electric Grinder Lacks Power—I shall appreciate it if some of our readers will answer the following questions. I have a single-phase portable grinder which has two windings, starting and running, but the motor does not seem to have sufficient power when grinding. I should like to know if this motor could be re-connected for three-phase operation, eliminating the automatic cutout on the rotor. The motor has twenty-four slots ⅝ in. deep and 3/16 in. wide. The iron back of the slots is ⅝ in. thick. Inside diameter of stator is 3⅛ in., length of stator 2½ in., diameter of rotor 3 1/16 in. If this change is possible, what size wire and how many turns should be used and what will the pitch be? I should like to have it operate at 3,600 r.p.m.

I have a small blower motor which operates at 220 volts direct current and wish to change it to operate at 110 volts direct current. Will I have to reconnect the armature or should it be entirely rewound. The commutator has twenty-four bars and the armature has twelve slots.

Medina, Ohio. C. F. N.

In reply to the question asked by C. F. N. in the March issue, the motor for the portable grinder can be rewound and connected for three-phase operation. I would suggest that he use No. 21 gage wire, thirty-two turns per coil with a coil spread of six slots, making a coil occupy slots 1 and 7. There will be twenty-four coils, eight coils per phase, four coils per phase per pole, as the motor will have two poles. It will develop approximately 3,600 r.p.m. The winding should be connected series-star for use on 220 volts.

Muncie, Ind. GEORGE CROPPER.

* * * *

What Causes this Magnet Switch to Stick?—We have on a crane hoist a 440-volt a.c. magnetic limit switch which fails to open about one-half of the time when the current is taken off the magnet coil. Although the core is laminated, there is apparently enough magnetism left to hold the switch in. All of the working parts are clean and free. Will someone kindly suggest a remedy for this trouble?

Selby, Calif. J. T. C.

In answer to J. T. C. in a recent issue I believe his trouble can be remedied quite easily. If the armature, the element which moves in the core of the solenoid, is examined it will likely be found that the brass shell is worn through or is very thin, thus allowing the residual magnetism to hold the switch closed. Either the core center is protected by brass or the plunger is brass covered, so that iron will not adhere to iron. Renew or thicken the brass shell and better results will likely follow. If the coil has a laminated keeper, it is probable that the copper rivets on the face of the latter are worn down, so that the two sections come too close together in action. The release may be designed to be hastened by a spring which, however, may be too weak to open the switch instantly when the power is off. Without knowing the shape of the coil controlling the switch, it is hard to cover all details when suggesting a remedy.

New Britain, Conn. H. S. RICH.

* * * *

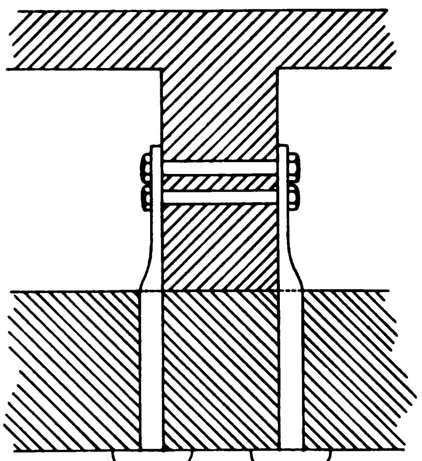
Supporting Load from Concrete Ceiling—In the rearrangement of the plant with which I am connected, we frequently find it necessary to suspend conveyors, motor platforms, countershafts, heavy radiators, and similar equipment from the ceiling of a reinforced concrete building. I am wondering if any of the readers of INDUSTRIAL ENGINEER have any information on how heavy a load can be supported from expanded bolts. I would also like to find out what other readers consider the best method of fastening equipment to the ceiling.

Chicago, Ill. E. D. F.

Referring to E. D. F.'s question in the April issue, the use of expansion bolts is too uncertain when heavy weights must be supported, particularly if there is much vibration as with shafting, motor platforms, etc., as too much depends on getting exactly the right diameter of hole.

A very convenient and inexpensive way of providing for the support of pipes and other light-weight fixtures is to set strips in the beam forms at the time the beams are poured and thus leave a groove on each side near the bottom. For heavier work, some of the patented, steel T-groove sections are excellent, although they are expensive if the whole building is to be equipped for future requirements.

I suspect, however, that E. D. F.'s case is like our own and that most of the beams and floors have no provision made for attaching anything to the ceiling. For a beam ceiling, we have found the scheme shown in the illustration very satisfactory for shaft hangers, etc. A ½-in. by 2-in. bar is forged, for a portion of its length, into a ¾-in. round bar and threaded. Two of these threaded straps are used on each beam, the two being held by ¾-in. bolts, placed close together at the center of the beam. For heavier work, the size of the straps and bolts can be correspondingly increased, being careful, however, not to load the concrete beams unduly. We have a heavy crane monorail supported in a similar way with angle-iron brackets and used for loads of five to ten tons with entire satisfaction.



Threaded straps bolted to the concrete ceiling beams, are a convenient means of supporting moderately heavy loads.

For general purposes, however, if the floor above is accessible a through-bolt with a fairly large washer, sunk so that the top of the head comes flush with the floor, and with the opening patched with grout in which about 25 per cent of the sand has been replaced with fine, cast-iron chips, will make a very satisfactory job. We have some very heavy trucking on concrete floors and find that such patches, if of reasonable depth, are stronger than the original floor.

Care must be taken in drilling both beams and floors to use sharp-pointed drills and strike light blows, particularly when breaking through, so as not to flake out big pieces and weaken the structure.

Plant Engineer, H. D. FISHER.
New Haven Pulp and Board Co.,
New Haven, Conn.

* * * *

Installing Signal Lamp on Single-phase Electric Furnace—Can any of our readers tell me how to install a signal lamp on a single-phase electric furnace?

There is a switch on the primary side of the transformer that furnishes current for the furnace, and I wish to find some way of installing a light between the top carbon electrode and the bottom contact, so that when the switch is released by a short circuit from a piece of metal falling against the carbon electrode, we can tell by this light whether the electrode has been raised high enough to break contact with the metal, before throwing in the switch.

The winding in the transformer forms a permanent circuit, so that we cannot apply any outside source of current to operate this light. It would save us considerable money if we were able to connect up a light of this kind, as the cost of carbon electrodes and contacts for the switch runs into considerable money. I shall appreciate very much any suggestions which you can give me.

Michigan City, Ind. P. V. H.

Answering P. V. H.'s request in the March issue, he does not give the voltage of the power supply, but I will try to cover three possible conditions. These are only suggestions, but I believe that they are worth trying, which can be done at small cost.

If the power supply is 220 volts, connect one 110-volt lamp around, or in shunt, with each side of the main switch, thus putting the lamps in series with the furnace transformer. If there is a short across the electrodes the lamps will burn brightly; otherwise, they will burn dimly. The larger the lamps used, the better they would indicate. In any event, the lamps used should all be of the same wattage.

For a 440-volt supply, two lamps should be connected in series around each side of the main switch, as indicated above.

If your supply is 2,200 volts or over, it would be necessary to use a small transformer with the primary wound for the supply voltage. The primary of this transformer should be shunted around one side of the main switch in series with the main transformer, with the secondary connected to a pilot lamp. It would, of course, be necessary to shunt a suitable switch around the other side of the main switch in order to complete the primary circuit when testing.

If desired, a voltmeter could be used

in place of the lamps in the foregoing schemes, with just as good or perhaps better results. C. L. HARTMAN.
The Hartman Electrical Works,
Greeley, Colo.

* * * *

Effect of Armature Coil with Reversed Polarity—Sometime ago this question was raised in our shop: Will a reversed polarity coil in an armature burn out while running or what effect will it have on the armature?

I contend that in order to burn out a coil a heavy current must flow in that coil, which could only be caused by a short circuit. As all coils are connected in series, current of the same amount would flow in each; if one were reversed it would oppose the action of the others and having only the same amperage through it as the others it could only oppose with the strength of one coil, and would neutralize one armature coil.

I should like to hear from some of the readers of INDUSTRIAL ENGINEER on this question.
McKeesport, Pa. E. K.

Answering E. K.'s in the February issue of INDUSTRIAL ENGINEER, you are right in saying that when two or more coils are in series the same current flows through them all. This being the case the reversed coil will not be heated any more than the remaining coils in the series. Also you are correct in your inference that one reversed armature coil will neutralize one other coil. I might add that when the machine is running as a motor, a reversed coil in the armature would tend to turn the armature in the opposite direction. Theoretically, this will lessen the torque of the motor but in practice this effect might not be noticed as there are many coils in most commercial armatures.

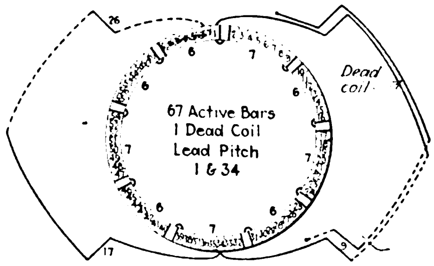
When the machine is running as a generator a reversed armature coil will produce less voltage than the other side. Therefore, there will be cross currents in the armature which may be the cause of a noticeable rise in temperature.
Concord, Mass. DONALD FERGUSON.

* * * *

Winding Data for Rotor of Repulsion-Induction Motor—Can someone tell me the correct way to wind the rotor of a single-phase, repulsion-induction motor which has four poles and four brushes? The motor appears to be about 1 hp. The nameplate is missing, but the motor has thirty-four slots and seventy-six bars. The coils have four turns, wound two in hand, using No. 13 d.c.c. wire. The coil pitch is 1 and 9. Nine pairs of the bars were shorted, I believe in the order X, 7X, 6X, 7X, 6X, 7X, 6X, 7X, 6X, 6, the X representing a shorted pair of bars. I have tried six or seven common pitches without success, the motor locking at certain points in each case. Is it impossible to start up with this commutator?
Lewistown, Pa. G. R. F.

In answer to G. R. F.'s question in the March issue, the motor in question has only thirty-four slots and therefore when a 76-bar commutator is used there will be eight bars too many. Inasmuch as the number of bars must be odd when the number of coils per slot is even, it follows that there will be a dead coil and one more bar, nine in all, will have to be idle. When laying out this winding, first short the bars as shown in the drawing and space them evenly.

When this is done consider each pair of shorted bars as one bar, when counting off the lead pitch, which can be 1-and-34 or 1-and-35. Failure to con-



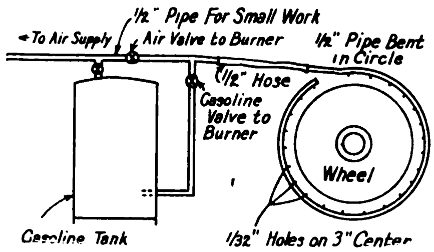
When laying out and connecting this winding each pair of shorted commutator bars should be considered as one bar.

sider and use the shorted bars as one bar is what has caused the trouble mentioned by G. R. F.
Detroit, Mich. A. C. ROE.

* * * *

Tire Heater for Wheels of Mining Locomotive—I should like to know where I can obtain a device for heating the tires for removal from the wheels of mining locomotives. The wheels are about 14 in. in diameter. I should prefer some device that, if possible, will not require the removal of wheels from under the locomotives in order to take off the tires and can use kerosene or gasoline as a fuel. If any reader of INDUSTRIAL ENGINEER has made an outfit which will do this work I shall appreciate it if he will give me details.
Kilday, Ky. C. F. K.

In a recent issue of INDUSTRIAL ENGINEER, C. F. K. asked for details of a tire heater for mining locomotive wheels. Perhaps he can use the heater described below, which I made and have used with good results on wheels up to 72 in. in diameter.



Construction of simple heater for removing tires from small locomotive wheels.

As will be seen from the illustration, this heater is very simple, consisting essentially of a circular burner and a gasoline tank. The burner is made from a piece of ½-in. pipe bent into a circle about 4-in. in diameter larger than the diameter of the wheels on the locomotive. Around the inner surface of the burner are a large number of 1/32-in. holes drilled on 3-in. centers. One end of the pipe is capped and the other is connected by a ½-in. rubber hose to the compressed air line and the gasoline feed line.

A 5-gal. gasoline tank will be large enough for small work. The air in the gasoline tank should be kept at about 70 lb. pressure to insure satisfactory results.

When operating this heater, be sure to open the air valve to the burner before turning on the gasoline feed valve. Both valves should be regulated according to the amount of heat required. In shutting off the heater, close the gasoline feed valve first.
Chief Electrician, EARLE N. DILLARD.
Booth-Kelly Company,
Springfield, Oregon.

* * * *

Winding Data for 15-hp. Motor—Will some reader of INDUSTRIAL ENGINEER please show me how to figure the winding of a motor in which the outside diameter of the stator lamination is 17 in., and the inside bore is 12½ in. The axial length of the core is 4½ in. The primary slots are 1¼ in. deep and the slot width is $\frac{7}{16}$ inches. The tooth width is ¼ in., and there are seventy-two slots. I want this motor to have six poles and develop 15 hp.
Fayetteville, N. C. E. A. K.

In answer to E. A. K. in the January issue, in order to calculate the winding from the data given, the first step is to check the amount of iron in the core to determine if the required rating can be secured. Horsepower $= K \times D^2 \times L \times$ r.p.m., where $K = .00002755$, $D =$ diameter of bore, $L =$ length of bore. Then horsepower $= .00002755 \times 12.5 \times 12.5 \times 4.5 \times 1{,}200 = 23¼$ hp., approximately. The frame is thus of ample size for the rating required.

Next, the cross section of iron below the slot is determined as follows: The outside diameter of the core, 17 in., minus the bore, 12½ in., divided by 2, equals 2¼ in. Then 2.25 minus the depth of slot, or $2.25 - 1.25 = 1$ in., or depth of iron under the slots. The cross section in square inches equals $L \times$ depth, or $4.5 \times 1 = 4½$ sq. in. As the total flux per pole is divided into two paths the total cross section is $2 \times 4½$ sq. in. or 9 sq. in.

Next, the total flux per pole must be determined. This is based upon the magnetic density allowable in the core below the slots. This density runs between 80,000 to 100,000 magnetic lines of force per sq. in. For the case in hand a density of 90,000 lines per sq. in. will do; or the total flux per pole equals $9 \times 90{,}000$, or 810,000 lines per pole.

Next, the turns per phase can be found by the formula: $T = (E_p \times 10^8) \div (4.44 \times \text{flux} \times f \times K)$, where T_p equals turns per phase, (f) is the frequency of the circuit, and (K) is the distribution factor, which depends upon the number of slots per pole per phase. (E_p) is the volts per phase and is equal to the line voltage in a series-delta connected winding and to line volts $\div 1.73$ for a series-star winding. Then assuming a 220-volt line and a series-delta connection the turns per phase equal $(220 \times 100{,}000{,}000) \div (4.44 \times 810{,}000 \times 60 \times .958) = 108$ turns or as there are seventy-two coils there will be $72 \div 3 = 24$ coils per phase and $108 \div 24 = 4½$ turns per coil. As it is impossible to have 4½ turns per coil the only alternative would be to use a five-turn coil and reduce the coil pitch.

There are 108 turns per phase; then each turn develops $220 \div 108 = 2.037$ volts. With five turns per coil there would be $5 \times 24 = 120$ turns per phase or, $120 \times 2.037 = 244.44$ volts per phase. Then the chord factor required to reduce this voltage to 220 would be $220 \div 244.44$, or .90001 which is the sin of 64 deg. 10 min. or an angle of 128 deg. and 20 min. Now the electrical de-

grees below slots equals $72 \div 6 = 12$ slots, and 180 deg. $\div$ 12 = 15 deg. The coil pitch equals $128 \div 15 = 8.5$, or 9. Then a 1-and-10 pitch could be used; the chord factor would be the sin of $(9 \times 15 \div 267)$ deg. 30 min. or .92388, and the line voltage would be $244.44 \times .92388 = 225.8$ volts, which is close enough.

The size of wire is next found. For a machine of this size an allowance of 750 circ. mil per amp. is good practice. A 15-hp., 220-volt, three-phase motor will draw about 40 amp. per line; then the amperes per phase for a series-delta connection will be $40 \div 1.73 = 24$ amp. Then $24 \times 750 = 18{,}000$ circ. mil required. One No. 8 wire has an area of 16,510 circ. mil and one No. 7, 20,820 circ. mil. Two wires in parallel would make a better coil to wind; then each wire would have $18{,}000 \div 2 = 9{,}000$ circ. mil, corresponding to a No. 11 wire. Checking the slot to see if $2 \times 5 \times 2 = 20$ No. 11 wires would fit in each slot, 10 high by 2 wide, the diameter of one No. 11 d.c.c. wire, is .10075 in. and two would be $2 \times .10075$ in. = .2015 in. The slot is .4375 in. wide; then .4375 in. — .2015 in. = .236 in. for slot insulation, which is ample for 220 volts. The height equals $10 \times .10075$ in. = 1.0075 in.; 1.25 — 1.0075 = .2425 in. which indicates that a larger size wire can be used. A No. 10 wire has an insulated diameter of .112 in., or .224 in. for two. This still leaves ample room for slot insulation. Next checking the height, $10 \times .112 = 1.12$ in. which leaves 1.25 — 1.12 = .13 in. clearance.

Then the stator winding data will be seventy-two, diamond-shape pulled coils of five turns of two No. 10 d.c.c. wires in parallel, pitch 1 and 10, connected series-delta in eighteen groups for four coils per group.

Detroit, Mich. A. C. ROE.

* * * *

Operating 60-Cycle Repulsion Motor on 25 Cycles—I have a ½-hp., 110-volt, 60-cycle, single-phase repulsion motor with a new winding in the rotor. The only current available here is 110 volts, 25 cycles. I wanted to test this motor out and when I connected it to the line it would start nicely, but as soon as the mechanical switch cut out the rotor would stop instantly, as nearly as I could see. Then just as soon as the brushes got back on the commutator the rotor would immediately start and then stop again and so on.

The coil pitch and commutator connections are the same as in the old winding. I have checked up the winding for shorts and polarity and it appears to be all right. I should like to know (1), if the motor will run satisfactorily on 60 cycles. (2) What makes the motor start and stop this way on 25 cycles? I shall appreciate any suggestions which readers of INDUSTRIAL ENGINEER can give me.

Massena, N. Y. F. A.

In reply to F. A.'s question in the March issue, a single-phase induction motor which starts on the repulsion principle has series-motor characteristics while starting and when the mechanical governor operates it converts the motor into an induction motor, with constant-speed characteristics. As a series-type motor the speed will rise to the point necessary to operate the governor regardless of the frequency, but when the governor acts the motor becomes an induction motor with a definite speed determined by the frequency. Assuming that this is a four-pole motor, the governor will be set to operate at about three-fourths synchronous speed or 1,350 r.p.m. on 60 cycles. When this motor is started on 25 cycles the governor will act at this speed, whereupon the motor is converted into an induction motor with a maximum speed of 750 r.p.m. The rotor will be jerked down to this speed by the braking action on the rotor, due to the tendency to operate as a generator. This motor would burn up on 25 cycles, even if the governor were re-set. The flux density would tend to increase in the ratio of 60 to 25 and the exciting current would become destructive.

Electrical Engineer, E. L. CONNELL.
Van Dorn Electric Tool Co.,
Cleveland, Ohio.

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In answer to the question asked by F. A. in the March issue of INDUSTRIAL ENGINEER, I believe his motor will run on 60 cycles, 110 volts when the starting mechanism is properly adjusted. The motor he describes is not a repulsion motor except when starting. This motor, together with some Wagner, Century, Westinghouse, and other makes of motors, uses the repulsion-induction principle on starting and employs a mechanical device operated by centrifugal force to push the brushes away from the commutator and at the same time short-circuit the commutator from within when the motor attains synchronous speed. It then operates as an ordinary induction motor.

If F. A. will examine this starting mechanism he will probably find that it is dirty or out of adjustment and that the commutator is not being short-circuited, which causes the brushes to drop in again for a new start. Take into consideration the fact that his testing circuit is only 25 cycles, he can only expect 25 divided by 60, or approximately 41 per cent of the 60-cycle speed, which I do not believe is enough to operate the starting mechanism properly. Also, at 25 cycles, 110 volts is much too high a voltage and if it were applied long enough it would likely damage the winding.

It will be well, however, to examine the starting mechanism to make sure that it is not dirty or binding anywhere. If it was not disassembled from the armature during the winding process, it is probably gummed up with insulating varnish.

San Angelo, Tex. CURTIS EBNER.

* * * *

With reference to F. A.'s question in the March issue, from his description of its performance it is apparent that this is a repulsion-start, induction-run type of machine, and that the trouble is due principally to the motor being operated on a frequency below rating, with the short-circuiting mechanism adjusted for 60-cycle operation. During the starting period the machine operates as a repulsion motor and displays characteristics similar to those of a series type (without load), in that a speed may be attained which greatly exceeds the rated r. p. m., and which bears no definite relation to line frequency. In a motor whose full-load speed is 1,750 r.p.m. (four poles, 60 cycles), the short-circuiting device would operate at approximately 1,500 r.p.m. Simultaneously with the operation of this device, the machine assumes the characteristics of a squirrel-cage type, which runs slightly below synchronous speed. If driven above that speed it tends to act as an induction generator, energy being required. In this case, as the speed of the armature is 1,500 r.p.m., 100 per cent over the 25-cycle synchronous speed of 750 r.p.m,. a sudden dynamic braking action results.

In the case of a 60-cycle motor operating on a 25-cycle circuit, care should be exercised in applying rated voltage to the machine, inasmuch as the effect produced will be the same as the application of $(12 \div 5)$ times normal voltage, or, in the case of a 220-volt machine, 528 volts.

Denver, Colo. EDWARD H. HAUSLER.

* * * *

Correcting Power Factor by Synchronous Condenser—I wish to submit the following problem to our readers: *A* is a distributing station supplying power to four feeders, *B*, *C*, *D* and *E*; *B* takes 4,000 kw., *C*, 3,500 kw., *D*, 3,000 kw., and *E*, 2,000 kw. The power factor of these loads is: *B*, 80 per cent, *C*, 78 per cent, *D* 75 per cent and *E*, 72 per cent, all lagging. It is desired to install a synchronous condenser at station *C*, to give 95 per cent power factor. Would it make any difference in the size of condenser required at *C* if stations *B*, *D*, and *E* were to correct their power factor to unity instead of running at 80, 75 and 72 per cent respectively, as at present, (1) in case station *A* has ample generator and exciter capacity and (2) in case this capacity is just enough to carry the load?

Belleville, Ont., Can. J. H. G.

The following will answer the question by J. H. G. in a recent issue:

(1) Under the first set of conditions, to raise the power factor to 95 would require a synchronous condenser with a capacity of 4,100 kva. operating at zero power factor leading. (2) In the second case if stations (B), (D) and (E), should have their power factors raised to unity, a synchronous condenser having a capacity of 1,000 kva. will be required, operating as before, at zero power factor leading.

The foregoing values are based on slide-rule calculations and the actual rated capacity of the condenser must obviously be somewhat larger to include some slight losses as well as to give a little extra capacity to insure satisfactory operation.

C. OTTO VON DANNENBERG.
The J. G. White Engineering Corp.,
New York, N. Y.

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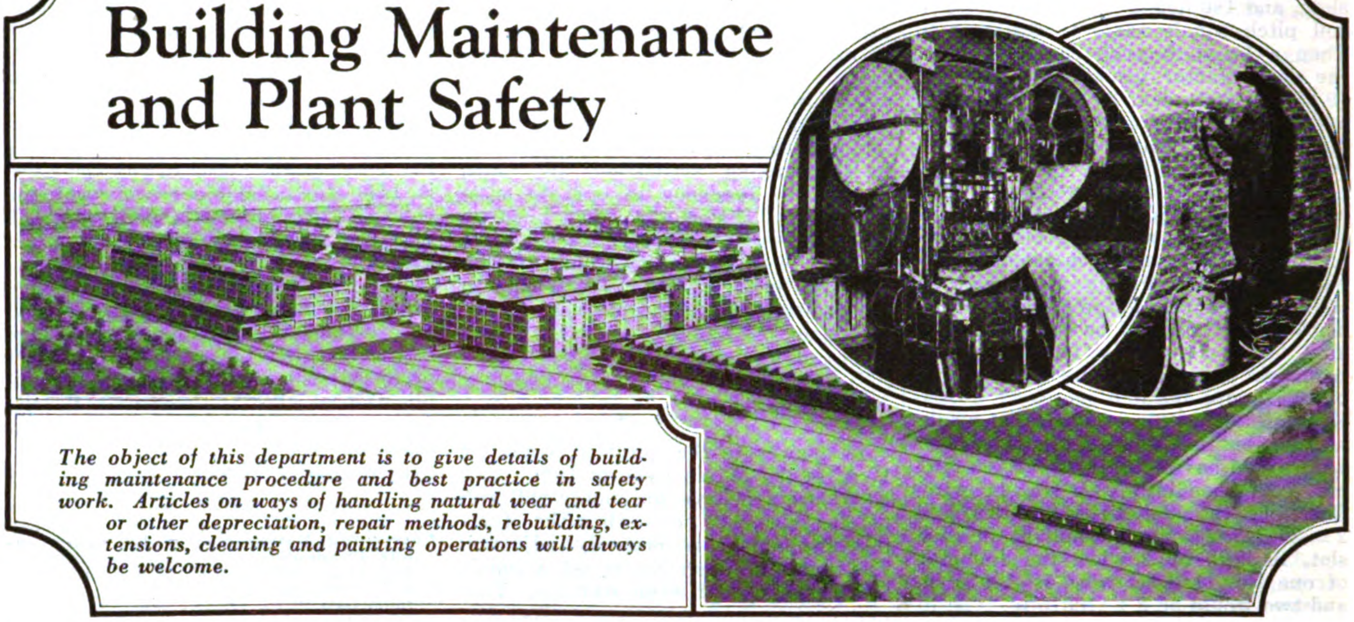
In answer to question by J. H. G. on power factor correction in a late issue, I am offering two solutions to the problem.

To correct the power factor at (C) to 95 per cent, a synchronous condenser of 1,717-kva. capacity is required. The power factor of the other loads has no effect on the power factor at (C).

To correct the power factor of the station to 95 per cent requires a synchronous condenser of 5,190 kva. The condenser may be placed at (C) or any other point, or smaller units at each point. It makes no difference in the size required where the synchronous condenser or condensers are placed.

Boston, Mass. D. E. WALCH.

Building Maintenance and Plant Safety

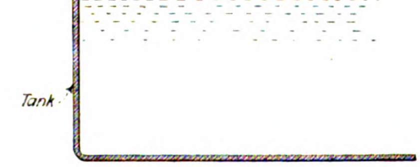


The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Automatic Control for Keeping Water Level Constant

A SIMPLE but very practical method for fitting an easily-made automatic control valve to a water tank is shown in the illustration. Although this improvised automatic valve was devised for use in connection with a dipping tank used in a forge shop, the idea is applicable in many instances where it is desired to maintain a certain quantity of water in a tank which is filled from a pipe controlled by a valve.

As shown, when making this automatic control an inexpensive bleeder or drain cock is screwed in to the end of the inlet pipe. A wooden lever is then slotted and secured with small bolts to the lever handle of the cock. The opposite end of the lever is floated on a 1 ft. length of a 6-in. by 6-in. beam. The float is thoroughly painted to protect it as much as possible from the water. The float is large, and has sufficient weight to operate the cock under any conditions, opening it when the level of the water falls and closing it when the water reaches the required height.



A wooden float is attached by means of a rigid arm to the handle of the drain cock on the end of the inlet pipe.

The total cost of this device is not much more than the cost of the cock, as the material for making the float and lever are available in any shop.

Washington, D. C. G. A. LUERS.

Selecting the Proper Extinguishing Agent for Various Classes of Fires

FIRE PROTECTION should consist largely of providing proper equipment to handle the fire when it starts and knowing what to do with this equipment in emergency. A large proportion of fires, if properly handled when discovered, can be put out with but little loss. One big mistake in the use of portable extinguishers for the little fires lies in considering that all kinds of portable extinguishers are equally good for any kind of fire. This is not true, as all fires are not alike; neither are the contents of all extinguishers alike nor do they extinguish fires on the same principle. The accompanying chart gives one method of rating the comparative merits, on the fire protective scale, of each of four types of chemical fire extinguishers and extinguishing agents. Before deciding on any extinguisher it is well to consider four essential points: (1) The principle of the extinguishing agent employed; (2) the characteristics of that agent; (3) the quantity of the agent used; (4) the method of operating the extinguisher.

Fire may be put out with an agent having a "cooling" effect, or with an agent having a "blanketing" effect. Nearly all extinguishing agents produce both effects but not to the same degree. Many fires, such as those in ordinary combustible materials—wood and rubbish—can be put out with either a "cooling" or "blanketing" agent. Other fires, such as those of oil, paint and greases, must be blanketed.

The "cooling" principle is employed in extinguishers whose extinguishing base or contents are water, soda solution, or calcium chloride solution. The "blanketing" principle is represented in two types of extinguishing agents: The "gas blanketing" type and "foam blanketing" type. Those which have a carbon tetrachloride base produce a heavy free gas which seeks the floor level. They have no cooling effect, but possess the advantage that their solution is a non-conductor of electricity, hence safe around live, high-voltage electrical equipment. Because of the ease in portability they are the best available for use on automobiles, motorboats, motor trucks and similar places. In the "foam" type of fire "blanketing" agent the "bubbles" generated form a wet foam which excludes oxygen long enough to allow the material that was burning to cool.

Water, because it is almost universally available, has been and always will be the most widely used fire extinguishing agent for exten-

sive fire fighting, but it is not used by itself to any great extent in portable fire extinguishers. An extinguisher employing water or a soda solution when installed in a place subject to freezing temperature, must be placed in a heated cabinet both to protect it and also because chemical reaction takes place sluggishly at low temperatures. Extinguishers using calcium chloride solution can employ solutions of such concentration that they will withstand temperatures as low as 40 deg. F. below zero. However, an extinguisher that discharges water or a soda or calcium chloride solution, although it can be used effectively on ordinary fires, cannot properly be recommended for use on extra-hazardous fires, such as those in oil, paint and so on, or for fires in live, high-voltage electrical equipment. Water and liquid chemical solutions will frequently spread an oil fire and are conductors of electricity. Other points are covered in the accompanying table, which was adapted from a chart copyrighted by the Foamite-Childs Corp.

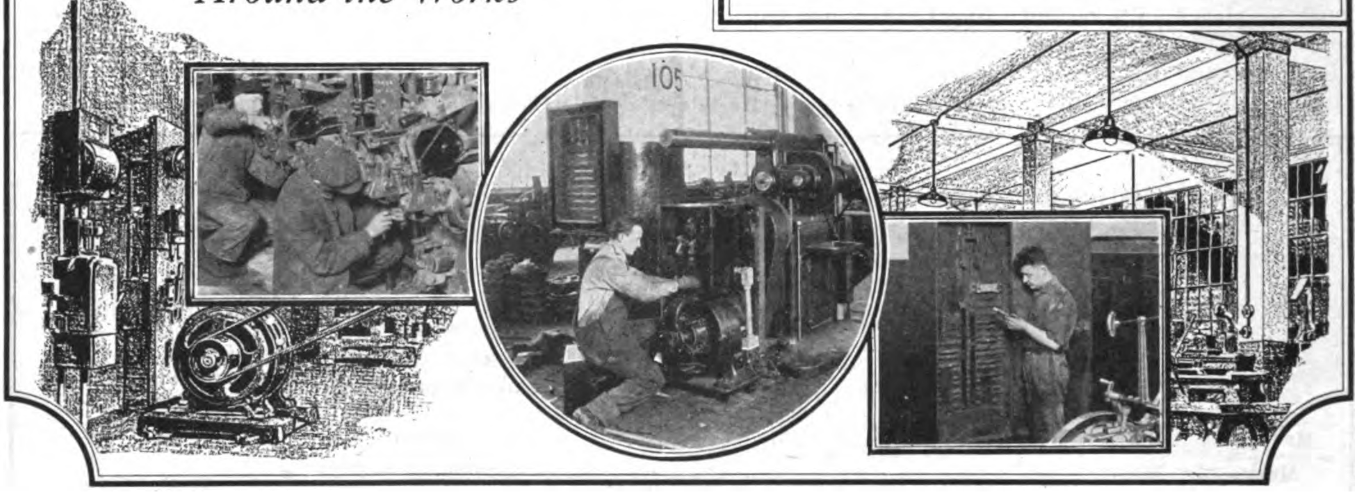
Characteristics and Operation of Four Types of Fire Extinguishers and Solutions

Type	Foam	Soda-and-Acid	Anti-Freezing	Tetrachloride
Chemicals Employed	Aluminum Sulphate—Bicarbonate of Soda with Foaming Agent	Bicarbonate of Soda Sulphuric Acid	Calcium Chloride (special grade) Safety Fuse Cartridge	Carbon Tetrachloride with important components for depressing freezing point, avoiding corrosion, etc.
Method of Operating	Invert	Invert	Invert	Pump
Method by Which Pressure Is Created	Chemical Reaction	Chemical Reaction	Burning of Safety Fuse	Pumping Action
Effective Range of Stream	30 to 40 Ft.	30 to 40 Ft.	30 to 40 Ft.	20 Ft. or More under full pump pressure
Rated Liquid Capacity of Most Common Size	2½ Gal.	2½ Gal.	2½ Gal.	¼ Gal.
Quantity of Principal Extinguishing Agent Produced	20 Gal.	2½ Gal.	2½ Gal.	Quantity variable — depends upon amount of liquid which comes in contact with heat of fire.
Nature of Principal Extinguishing Agent	Firefoam— A mass of bubbles filled with carbon-dioxide gas	Liquid Soda Solution	Liquid Calcium Chloride Solution	Free Gas Produced when liquid is vaporized by heat of fire.
Principal Extinguishing Effect	Blanketing	Cooling	Cooling	Blanketing
Is It Recognized as Adapted for Use On: Class A Fires — Wood, Textiles, Rubbish, etc.	Yes Best Available For use in all places involving Class *A* fires because of desirable characteristics not possessed by any other extinguishing agent (fireproofing effect; smaller wetting effect; etc.) Must be kept in heated cabinet when installed in places subject to freezing temperatures.	Yes For use in places *not* involving oils, greases, etc., in any way. Must be kept in heated cabinet when installed in places subject to freezing temperatures.	Yes For use in places *not* involving oils, greases, etc., in any way. Does not require protection at temperatures down to 40 degrees below zero.	No Other types are better adapted for Class *A* fires. This type good only under most favorable conditions because of: small size; difficulty of confining gas at seat of fire; force, range, and duration of stream not automatically assured; operator cannot devote entire attention to directing stream on fire; must be used with caution in small rooms.
Class B Fires — Oils, Greases, Etc.	Yes Best Available For use in all places involving Class *B* fires because of characteristics not possessed by any other type.	No Because ordinarily it has little or no blanketing effect.	No Because it has no blanketing effect.	Yes But foam type is better adapted for Class *B* fires. This type good only under most favorable conditions because of: small size; difficulty of confining gas at seat of fire; force, range and duration of stream not automatically assured; operator cannot devote entire attention to directing stream on fire; must be used with caution in small rooms.
Class C Fires — Electrical Machinery	No Except on low voltage when use with caution, or where current is likely to be turned off. Stream is a conductor but a poor one.	No Except on low voltage when used with caution, or where current is likely to be turned off. Stream is a conductor but a poor one.	No Except on low voltage when used with caution, or where current is likely to be turned off. Stream is a conductor but a poor one.	Yes Best Available For Class *C* fires, especially where current is not likely to be turned off, because the stream is a non-conductor.
•Class D Fires — Pleasure Automobiles, Commercial Trucks, Etc.	No Because of size; not splash-proof; subject to freezing.	No Because of size; not splash-proof; subject to freezing.	No Because of size; not splash-proof.	Yes Best Available For Class *D* fires because of desirable characteristics not possessed by any other type.

•The letter *D* is for convenience, no letter having been assigned to this class by Underwriters' Laboratories.

Electrical Service
Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



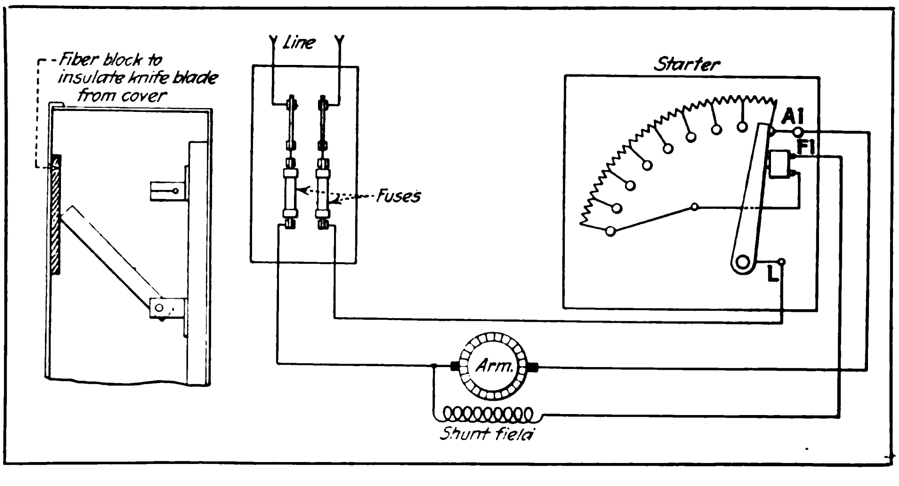
Trouble Caused by Switch Blade Touching Switch Cover

A RATHER unique case of trouble occurred on the 15-hp., 230-volt, d. c., motor driving a pump in our power house. The starting equipment consists of a 100-amp., double-pole, enclosed-type, fused safety switch and a hand starter connected as shown in the accompanying diagram. The motor is started and stopped several times a day. On one occasion each time the operator tried to re-start the motor, he found that the fuses were blown. After checking up the load and finding it well within the motor rating and also ascertaining that there were no grounds on the circuit, I felt that the operator must be starting the motor too quickly. I watched him carefully the next time he started, but found that he started the motor in the correct time. The motor ran perfectly for a half hour and was then shut down by opening the safety switch. I found that both fuses were again blown.

Upon looking over this switch I noticed the paint was burnt off the inside of the box and two small blisters burnt on the cover in line with the top of the switch blades. This gave me a clue. I found that when the switch was fully opened, both switch blades touched the inside of the cover. Of course, the circuit from the line was broken when this contact was made, but the motor was generating voltage at the moment the switch was pulled, so that a circuit was formed through the two knife blades of the switch, through the switch cover and thence through the starter and leads to the motor brushes, as shown in the accompanying diagram. This was really a dead short across the armature. The current built up in this circuit was heavy enough to blow the fuses which, of course, opened the short circuit. In other words, what we had was a very strong dynamic braking circuit which would have brought the motor to a dead stop very quickly had not the fuses blown.

The trouble was very easily corrected by bolting a piece of ¼-in. fiber inside the switch box as shown in the figure at the left of the diagram, so that when the blades were open they came in contact with the fiber instead of the metal of the cover. O. C. CALLOW.

Chief Electrician.
Trumbull Cliffs Furnace Co.,
Warren, Ohio.



When the safety switch was opened to stop the motor, the switch blades came in contact with the switch-box cover.

The fuses were blown because the cover made a short circuit across the armature of the motor which was acting as a generator while coasting to a standstill. The short circuit was across the switch blades at the point indicated in the illustration at the left of the diagram. The illustration shows how a fiber block was placed to insulate the switch blades from the cover.

How to Make a Neat and Tight Job of Exposed Wiring

WHEN running long lines of exposed wiring through a plant, a neat and tight job can be done by the following procedure, which involves only a few extra steps. Fasten the end of the line securely by two or three cleats placed close together; then go to the other end of the room, pull the line as tight as possible by hand and secure it by two or three more cleats. Go back to the beginning, place the next cleat 4½ ft. from the first one and gently pull down on the line beyond this cleat, in order to tighten

the line still more before fastening the cleat. Work along in this manner, placing one cleat after another and pulling down on the line just ahead of each of the cleats before tightening it.

When close to the last fastening remove it to another point farther ahead, again placing two or three cleats close together to hold the line firmly; otherwise it will slip. When turning a corner, if the line is to go very far, follow the same procedure that has been outlined.

In this way it is possible to put up a line that looks neat and is as tight as can be desired, without the use of a "come along" or other rigging often employed for this purpose.

New Britain, Conn. H. S. RICH.

An Easily Made Device for Warning Engineer of Time to Blow Whistle

TO FORESTALL a possible lapse of memory at whistle time, an operating engineer of a factory power plant has rigged up a device to warn him of the approach of the time the whistle must be blown. At this plant the whistle is blown at 8:00 a. m., 12:00 m., 1:00 p. m. and 5:00 p. m. As will be seen from the illustration, the metal dial of the engine-room clock was removed and ⅛-in. holes were drilled through just inside the circle of numerals at each of the above hours. Another ⅛-in. hole was drilled just outside the circle of numerals and above the numeral, XII. From each of the four inside holes, a narrow piece of ribbon steel projects. About ¼ in. of the projecting end of each piece is bent nearly at right angles in the direction of the rotation of the hands, as shown in the figure at the bottom of the illustration, while the other end is soldered to the end of an insulated copper wire which is glued to the back of the dial. A piece of ribbon steel slightly longer than the others, and with a bend of only 1/16 in. at its projecting end is similarly inserted in the outside hole and soldered to the end of a copper wire. The soldered joints and pieces of ribbon steel are insulated from the dial.

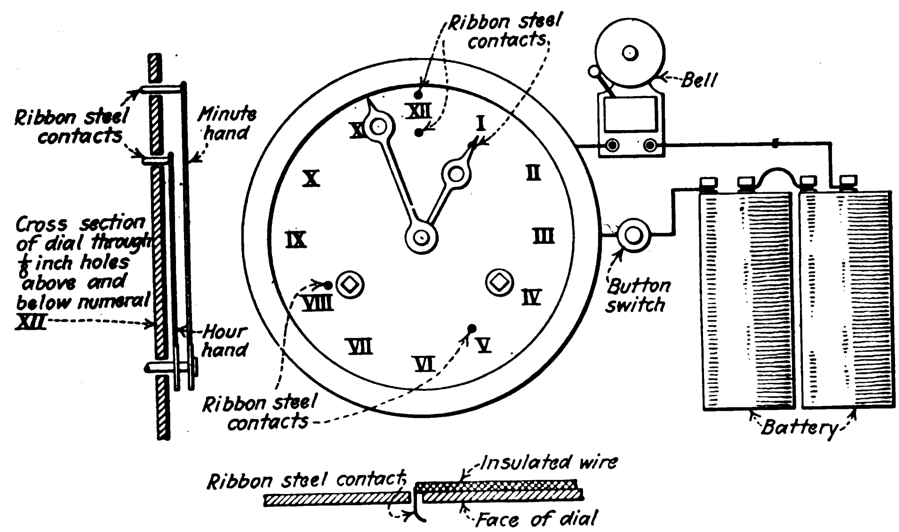
The four wires running from the four inside holes are joined to a single wire which is carried outside the casing of the clock and connected, through a button or snap switch, to one pole of a dry battery. The wire leading from the outside hole is also carried outside the casing and is connected through an electric bell to the opposite pole of the battery.

During a revolution of the hour, or short hand, the tip passes over the four inside holes, while in each revolution of the minute hand, the tip passes over the outside hole. Suppose one of the hours at which the whistle is to be blown, as at noon, is approaching. Then the hour hand will make contact with the bent end of the steel ribbon projecting from the hole beneath the numeral, XII, when the minute hand stands at, say, three minutes to 12, and it will still be in contact when the minute hand is exactly at noon. At this point the circuit will be completed from one side of the battery to the bell, through the bell to the ribbon steel contact at the top of the numeral, XII, through the minute hand, through the hour hand, through the ribbon steel contact at the bottom of the numeral, XII, thence through the button switch to the other side of the battery. Thus the bell will ring and warn the engineer that it is 12 o'clock and time to blow the whistle.

The steel ribbons are tempered so that they will spring back to their original position when the hands have passed by them. Their fineness and flexibility is such that they offer practically no resistance to the movement of the hands. The button switch was inserted so that the circuits may be kept open between 5:00 p. m. and 8:00 a. m. A. J. DIXON.

St. Louis, Mo.

Ribbon steel contacts are placed in the dial at points corresponding to certain hours and when the hands touch their contacts the circuit is completed and the bell rings.



Differentially-Connected Compound Motor Reverses When Operated Under Heavy Load

IF a compound motor has its field windings differentially connected, the direction of rotation of the motor may reverse when operated under heavy load.

A compound machine may be connected in two ways. One is to connect the two field windings so that the magnetic flux set up by both the series and shunt coils is in the same direction. When so connected the machine is said to be cumulative compounded. The second method of connection produces two fluxes that are opposed to each other, the weaker of the two partially overcoming the other and thereby producing a weaker magnetic field than would be produced by the shunt field winding alone. This second method is called differential compounding and will often cause trouble if the motor is operated on a heavy overload. The reason for this is explained below.

At light loads some differentially compounded motors will operate with apparent satisfaction, but at heavy loads may spark badly and at times flash over and then rotate in the opposite direction. For an explanation of this condition consider what is taking place inside of the motor at different load steps. At light loads the current in the series field winding is comparatively small and the magnetic flux set up by it is weak, while the flux set up by the shunt field winding is strong since it has impressed upon its terminals full line voltage, or nearly so, depending upon whether the machine is connected long shunt or short shunt.

Because of these conditions the flux set up by the shunt winding prevails and therefore determines the direction in which the motor will rotate at light or zero loads. With an increase of load the current in the series winding becomes greater, thereby setting up a greater magnetic field which, being opposed to the shunt field flux, neutralizes a portion of it and produces a weaker magnetic field. Since the load has been increased, the speed of the motor will probably not be affected to any great extent. With still greater loads the series field current becomes greater and in turn weakens the motor field. When the current in the series winding becomes great enough it will set up a flux which will entirely overcome that produced by the shunt winding and build up a magnetic field of the opposite polarity. In such a case the direction of rotation will be reversed.

The size of the feeders supplying a differentially-connected compound motor often affect the operation of the motor. If the feeders are rather small to carry the required load, the voltage drop over them may aggravate the conditions described above. If the feeders are too small the drop at the motor may be excessive at heavy loads. Since the resistance of the feeders remains practically constant, the voltage drop along them will be proportional to the current passing through them, as the drop is equal to the current times the resistance.

At heavy loads under such conditions the voltage across the shunt winding would be decreased and therefore the flux set up by this winding would be decreased. At the same time the current in the series winding would increase, thus increasing the flux set up by it. If these connections were as in a differential machine, the series field flux would be of the opposite polarity to that set up by the shunt winding and this would tend to weaken the field to a still greater extent. If these conditions were carried far enough the field set up by the shunt winding would be entirely neutralized and the field set up by the series winding would prevail and cause the motor to rotate in the opposite direction. Such a motor may rotate opposite to the direction desired at the time of starting because of the momentary heavy current in the series winding, this producing the effect described above. LEROY A. FRANCIS.

Instructor of Electricity,
Utica Free Academy,
Utica, N. Y.

Device for Recording Trips of Coal Car to Boiler House

IN A plant recently visited by the writer, a clever scheme was in use for keeping track of the number of trips the coal dump car made from the stock pile to the firing floor of a boiler house. Inasmuch as the dump car is always filled to capacity (3,000 lb.), this is an accurate method of keeping track of the coal consumption of the boilers, with a minimum of trouble and expense.

As can be seen from the accompanying illustration, a cam lever is pivoted on a stud projecting from the web of the rail of the dump car tracks. In running along the rail the car wheels depress the cam lever and thereby actuate, through the switch lever, the mechanism which controls the electrical connection. As soon as the car wheel has passed over the cam, the levers are snapped back to their original position by the spring *S*.

The electrical control mechanism, which is shown in the upper right-hand corner of the illustration, is enclosed in a sheet iron box. A ½-in. brass rod extends across the box from side to side, the ends being secured in fibre sockets. This rod is loosely encircled by two brass sleeves, the contiguous ends of which are notched to form a four-tooth ratchet clutch. The right-hand sleeve engages with a stationary toothed collar, as shown in the illustration. A spring is placed around the brass rod and between the left-hand fibre socket and left-hand sleeve in such a manner as to hold the sleeve teeth in mesh. The right-hand sleeve carries a fiber band through which projects a small, brass pin.

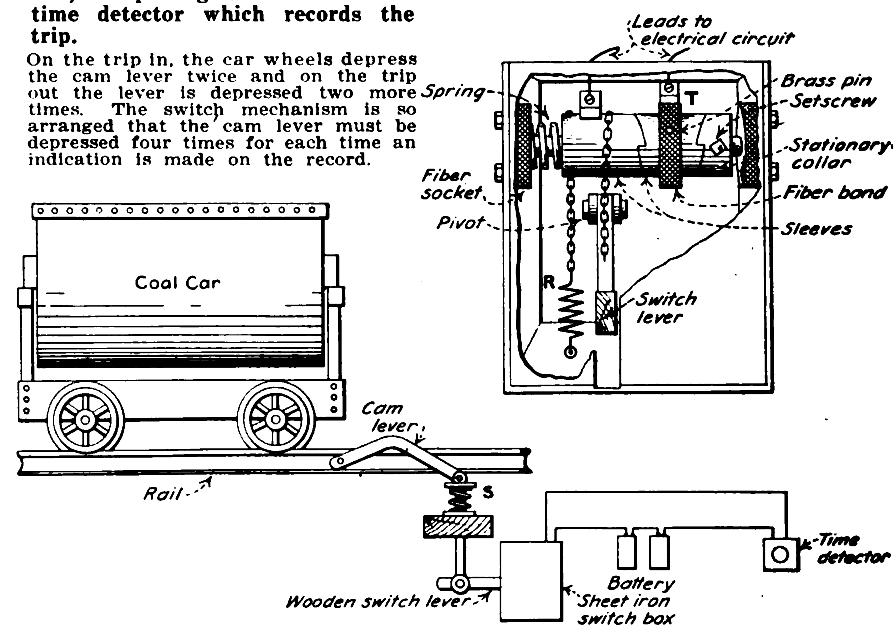
When the switch lever is depressed the sleeves are given a quarter turn by the pull of the chain which connects the switch lever with the left-hand sleeve. When the lever is released, the left-hand sleeve is pulled back to its first position by spring *R*, but the right-hand sleeve is kept from turning back by the clutch on the stationary collar.

As there are two wheels on each side of the car, the right-hand sleeve is given two quarter-turns while the car is being run into the boiler house, and another two quarter-turns while it is being run out. Hence, the sleeve makes one complete revolution each time a carload of coal is delivered, and at one point in the revolution the brass pin, which projects through the fibre band, is momentarily in contact with the tongue *T*, thus closing the electrical circuit to the time detector which is located in the chief engineer's office. A. J. DIXON.

St. Louis, Mo.

In passing over the cam lever the coal car actuates a switch mechanism, completing the circuit to a time detector which records the trip.

On the trip in, the car wheels depress the cam lever twice and on the trip out the lever is depressed two more times. The switch mechanism is so arranged that the cam lever must be depressed four times for each time an indication is made on the record.

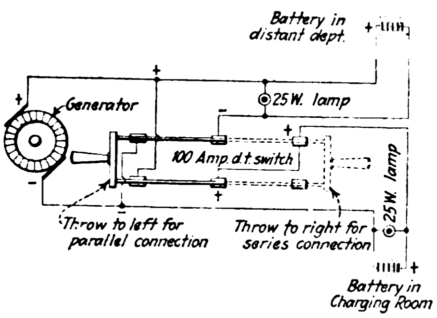


Switch for Charging Batteries in Parallel or Series

ON OUR General Electric battery-charging panel it is possible to take care of eight different batteries connected to only four switches, but inasmuch as some of the electric tractors are too large to be taken to the charging room they

are charged in their respective departments, an arrangement which saves considerable time and trouble.

As each switch on the main panel will care for two batteries it is possible to connect each pair in series and thus save fifty per cent of the ampere-output from the generator.



As indicated by conditions, storage batteries may be charged in parallel by throwing the switch to the left, or in series by throwing it to the right.

When one battery in a distant department is connected for charging it may be put in series with a similar sized one in the charging room, by using this switch, either in series or in parallel, with a pilot lamp for an indicator. All of the charging switches are capable of carrying 100 amp., and often a battery is given 90 amp. when not enough time can be spared for a normal charge. The parallel-series switch can be almost instantly thrown either way, as the pilot lamps indicate the load on the generator.

When the near and far batteries are being charged in series the pilot lamps will glow faintly; but if the far one is suddenly disconnected, the pilot on that line will light brightly, showing an open line. Then the switch is thrown to parallel and the rheostat re-adjusted for the remaining one battery in the charging room.

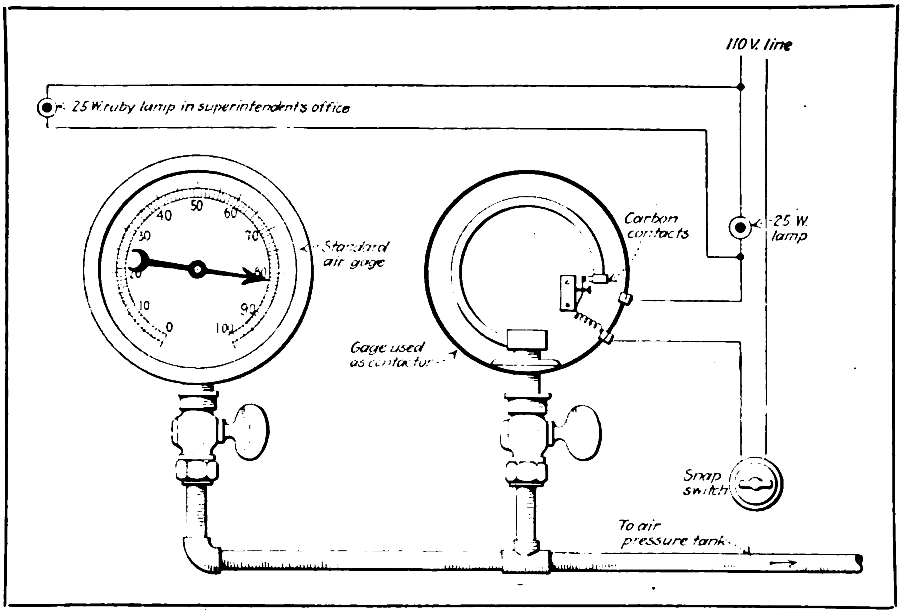
When only one battery is on charge at 45 amp., and the distant one is suddenly connected for a short charge, the load will drop to about 25 amp., by the meter. The switch is then thrown to the series side and the rheostat adjusted to bring the charging rate up to its normal value of 45 or 50 amp.

New Britain, Conn. H. S. RICH.

Air Gage Remodeled as Low Pressure Indicator

IN ORDER to insure maintenance of the proper air pressure for the operation of air lifts and ramming machines in a foundry, an old pressure gage was remodeled and used as an electric contactor to control two pilot lights, which are lighted when the pressure drops below a certain value and extinguished when it becomes normal. The changes made in the gage consisted in fastening near the end of the spiral tube a fiber insulating block carrying an adjustable thin brass finger, to which is connected one side of the snap switch. One side of the nearby pilot lamp is connected to the shell of the case and the 110-volt line is connected to both the switch and the lamp. In parallel with this lamp is another one placed in the superintendent's office. Both lamps are colored red to attract attention. When the lamps light it is an indication that the air pressure is low and another air compressor should be started.

As the spiral tube of the remodeled gage moves inward with a decrease in pressure a carbon block on the end of the tube makes contact with another block on a brass finger mounted on a fiber block, and lights the signal lamps.



Adjoining the contactor is a standard air gage by which the high and low limits are checked. When the air compressor is shut down for the night the snap switch is used to open the line.

The contacts can be set for any particular pressure by adjusting a small screw. As the device is set now, contact is made and the lamps lighted when the pressure drops below 80 lb. and extinguished when it again reaches that figure. The contacts are made of small carbon blocks fastened with countersunk screws. H. S. RICH.

New Britain, Conn.

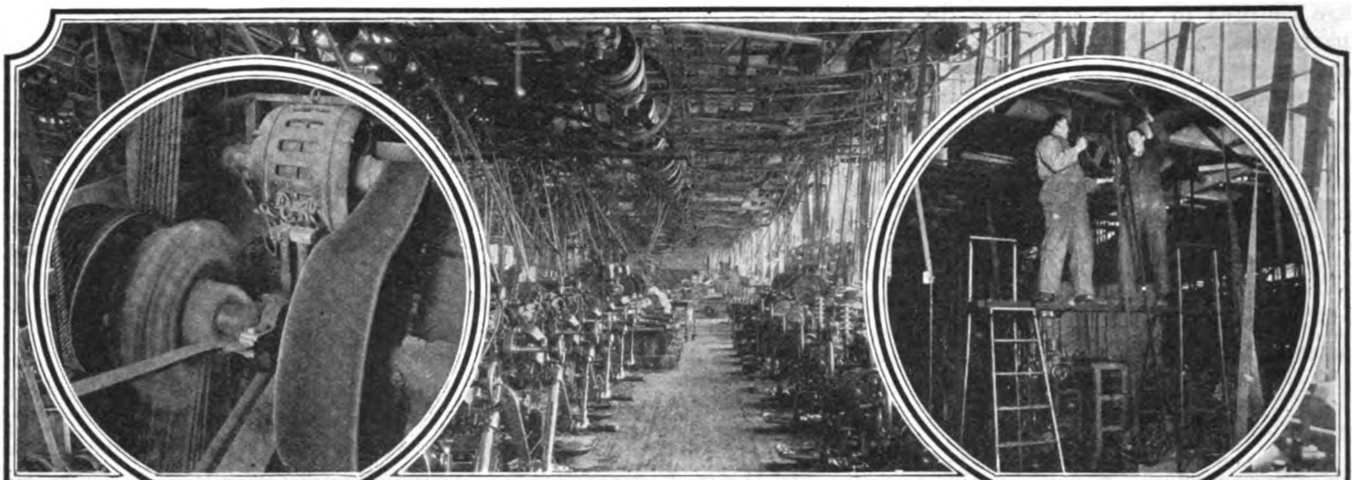
Burning of Switch Contacts Prevented by Shunt Across Motor Field

A REVERSING switch made by a well-known manufacturer for elevator service is subject to considerable burning of the contacts. The controller used with this switch is of the type that has one side of the line broken by a clapper or arm with carbon points. While we were working on an installation that had given a great deal of trouble we discovered that the burning of the contacts when the switch was opened was caused by a discharge from the motor fields. Accordingly, we shunted a suitable resistance across the fields and the burning stopped. Since then we have done that on several switches operating at different voltages and they have all worked satisfactorily, burning being greatly reduced.

Some time ago we ran into a similar situation on a 110-volt motor operated through a remote-control system. The controller had a clapper coil that automatically cut some resistance into its own circuit when the clapper was in. This resistance finally burned out, causing the clapper to keep going in and out and destroying its usefulness.

As an experiment, we connected up a mica socket, with a 110-volt lamp, in place of the resistance. The company had ordered a new resistance coil, but the results when the lamp was used were so satisfactory that it was not considered worth while to put the coil in.

Peoria, Ill. GEORGE RINGNESS.



Mechanical Maintenance of Power Drives

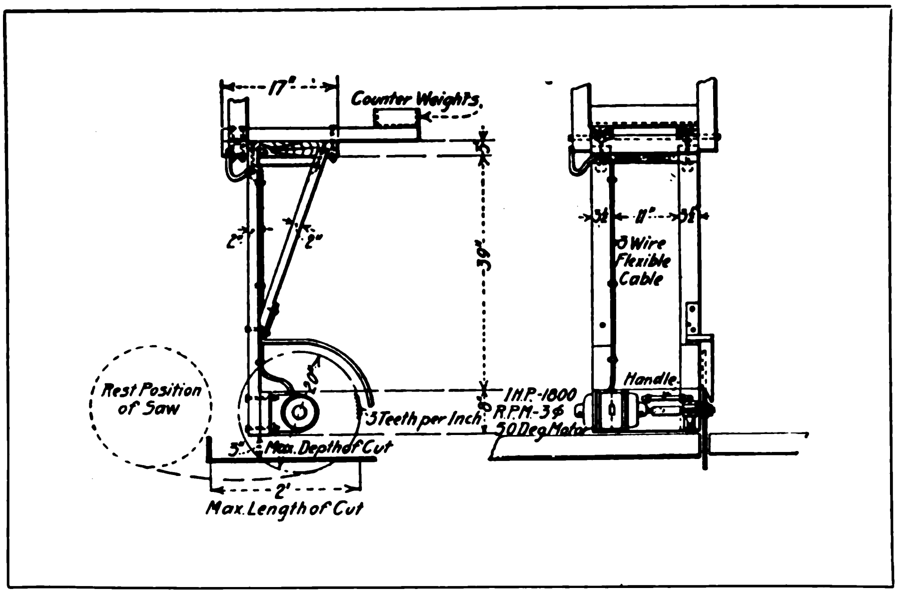
This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Advantage of Direct Drive for Swing Saw

DIRECT connection of motors to the swing saws in a Massachusetts box factory has, according to Joseph Franz, Stockbridge, Mass., allowed the size of motor used to be reduced from 3 hp. or 5 hp. to 1 hp., with a consequent saving in first cost and in energy consumption. The motor and saw are both mounted on an oak frame as the illustration shows and are connected by a short shaft running in a bearing. The shaft is about 1 in. larger than the motor shaft, which fits into and is keyed to it. The other end of the shaft is turned down to fit the saw arbor. An iron rod passing though the upper end of the frame fits in holes in supports hung from the ceiling so that the saw can be swung for cutting. A counterweight fastened on the upper part of the frame makes the saw hang in the proper position. The 20-in. saw shown is driven by a 1-hp., 1,800-r.p.m. motor, although a 3-hp. or 5-hp. motor was formerly used with the usual method of connection. This new construction eliminates the bearings at the top of the saw frame which supported the frame and also the belt drive to the saw, which was necessarily tight on account of being short and running in an almost vertical position when cutting. Practically all of the power is transmitted to the saw, and when idling the wattless current is small compared with that of the larger motor. There is no power wasted through a belt and the loaded bearings. Another advantage is that there is no belt to break and cause injury to the operator or nearby workmen.

Such a saw is not desirable for very heavy cutting, but it has been used satisfactorily on ⅞-in. stock of various kinds of wood.

Mounting the saw on an extension on the motor shaft makes possible the use of a smaller motor.



The Jingling Oil Ring Always Means Trouble

THE first time that I saw or had any experience with ring-oiling bearings on a generator was away back in 1891. We had just installed a Thomson-Houston compound-wound machine known as A 35. Soon after starting it up, and when the load was quite heavy, I noticed a peculiar jingling sound and was at a loss to account for it. We had carefully filled the bearings, which were of the self-oiling, ring type, with a good grade of dynamo oil; so I did not think anything was wrong with them, inasmuch as I had just felt them and found them cool. The light over the machine was poor, so that when I looked into the bearings the oil and rings appeared to be all right.

It so happened that there was more or less vibration of the machine and this, together with the suction-fan action of the commutator, which was just outside the bearing on one end, caused the oil gradually to work out of the bearing and

fly over the edge of the commutator in a fine spray. As I was not used to anything like this I did not grasp its significance until the bearing commenced to smoke, at which time the ring was jingling quite loudly and quick action was necessary to avoid serious trouble.

I stopped the suction effect of the commutator on our A 35 by the use of a tin apron bolted to the brush yoke and later the vibration, by bolting the machine down to heavy timbers set in concrete.

This incident taught me a lesson which I made use of only a year or so ago. I happened to be in a place where an electric water pumping outfit had been installed, and just about 5 min. after the owner had started it. I heard a jingling ring! At once I asked the owner if he had put oil in the bearings and quick as a flash he pulled the switch and did so. I then related to him my "ring" story which, in view of his own narrow escape from trouble, was quite amusing to him.

This story has a moral: Beware of the jingling ring on self-oiling bearings. HENRY MULFORD.

Electrician,
Patchogue Electric Light Co.,
Patchogue, N. Y.

Motor Speed Important Factor in Selection of Drive

THOSE who have had extensive experience with motor applications have repeatedly stated that the majority of motor failures are due to some mechanical cause, frequently originating outside of the motor itself. A common source of such mechanical trouble will invariably be found in defective drive conditions under which the motor operates.

The principal factor affecting the drive conditions, insofar as the motor itself is concerned, is the motor speed. Intimately associated with the speed are the actual means of transferring the power from the motor shaft to the load. Among these are direct connection, spur gearing, herringbone gearing, belting, flexible couplings, and chain drive.

The selection of the proper motor speed in combination with the best drive for a given application warrants considerable study in order to obtain the best results. Since the cost of motors of a given horsepower rating decreases with increase in speed, the mistake is often made of using a motor with too high a speed in order to save on first cost. After installation, the motor is a continuous source of trouble, not due to any inherent fault of its own, and quickly eats up in high repair and maintenance charges any saving that may have been effected in first cost.

The drive should be made as efficient as possible, so that the highest-speed motor compatible with good operating results can be installed. To determine the most economical installation it is usually necessary to balance the cost of a high-speed motor with a special drive fitting the application, against a lower speed motor with ordinary drive such as plain spur gearing.

The accompanying table of recommended motor speeds is based on extended experience with induction motors in heavy duty service.

Direct connection is the ideal drive and should be given preference wherever the service conditions warrant it. It must be remembered, however, that direct connection does not mean merely coupling a motor to a drive shaft which is itself geared to the machine proper, as in a triplex pump. This would be a gear drive in every way. For true direct drive, such as can be applied to a centrifugal pump, high-speed motors 1,800 r.p.m. and even 3,600 r.p.m. in the smaller sizes will give satisfactory service.

It frequently happens that a man takes charge of the electrical equipment in a plant after the installation is complete and finds that he has considerable trouble with some of his motors all of the time. If the fault lies with too high a motor speed for the type of drive in use, the trouble may manifest itself in a variety of ways, such as broken connections, loose rotor bars, sprung shafts with rotor rubbing on stator, and even broken frames. These are invariably caused by vibration. This is particularly true if the machine is gear driven. In this case, the vibration is not a visible chatter but is a fine, sharp buzz that can best be detected by the fingertips. Quite often crystallization results, which is very destructive to connections and other parts of the motor.

The following instance shows how the reduction of motor vibration corrected motor trouble in a large mill. A 25-hp., slip-ring induction motor, operating at 900 r.p.m. and connected by spur gearing to a triplex plunger pump, had been operating on intermittent service without trouble for several years. An increase in mill capacity necessitated operating this pump practically continuously. About this time troubles began to develop in the motor. Every month or so a rotor connection would break or burn off. An end bell cracked and had to be changed and the bearings seemed to wear at an abnormal rate. Eventually the rotor shaft was sprung so badly that a new rotor had to be installed. All this naturally entailed loss in production and considerable expense. It was noticed that in spite of the utmost care in aligning the motor and fitting the gears and pinions, considerable vibration was always evident in the motor. It was finally decided to interpose a flexible coupling between the motor and the pump and this effectively prevented further trouble with the motor.

Reference to the accompanying table indicates that for a 25-hp. motor and gear drive the best motor speed would have been 600 r.p.m.

Recommended Synchronous Speed of 60-Cycle, Induction Motors

Hp. Rating	For Belting, Flexible Coupling, Herringbone Gears, Chain Drive		For Plain Spur Gearing	
	Highest r.p.m.	Best r.p.m.	Highest r.p.m.	Best r.p.m.
1	1,800	1,800	1,200	900
2	1,800	1,800	1,200	900
5	1,800	1,200	900	900
7½	1,800	1,200	900	720
10	1,800	1,200	900	720
15	1,200	1,200	720	600
20	1,200	900	720	600
30	1,200	900	720	600
50	900	900	600	600
75	900	720	600	514
100	900	720	600	514
150	720	600	514	450
200	720	600	450	450

and the highest permissible speed 700 r.p.m. Therefore, had a motor of either of these speeds been originally installed, or a special drive, such as the flexible coupling later introduced, been used at 900 r.p.m., this motor trouble and the attendent losses would have been averted.

Comerio Falls, Bayamon, Porto Rico. FREDERICK KRUG.

Special Belt Eliminates Use of Idler Pulley on Commutator Slotter

RECENTLY it became necessary to put a commutator slotting machine in service before receiving the motor that was intended to operate it. The proper motor would have been mounted on the framework of the slotter and belted to the saw spindle by means of a sewing machine belt passed around an idler pulley, because the distance between centers of pulleys was only about 20 in. As a temporary makeshift, a 1-hp. motor was mounted on the floor with its pulley directly under the slotter pulley at its center of travel. Grooved pulleys were used on both shafts and the distance between centers, which was increased to 40 in., was depended on to keep the belt sufficiently tight throughout the 7-in. travel of the slotting saw in its movement from one end of a commutator to the other. It failed, however, to do so. With the belt adjusted to have sufficient tension to keep the saw moving in the center of travel the belt became taut before reaching either limit of travel and with the tension adjusted to suit both limits of the stroke the saw would jam in the center of its travel.

In order to overcome these troubles a machinist, who had used the device before, made a special belt consisting of ¾-in. by 1-in. pieces of single-ply belting riveted, allowing 1½ in. between centers, to a continuous backing of single-ply belt ¾ in. wide. The belt as a whole was then shaved to a wedge shape to fit into the grooves of the two pulleys. With 36 in. or less between the centers of the pulleys this belt pulls the saw around satisfactorily at all points of the travel and absolutely no trouble has developed since installing it. Some device of this kind was necessary because the size of the 1-hp. motor made it impracticable to install it in the space provided for a much smaller motor.

Brooklyn, N. Y. J. A. HORTON.

Making a Speed Reducer With a Large Range of Speeds

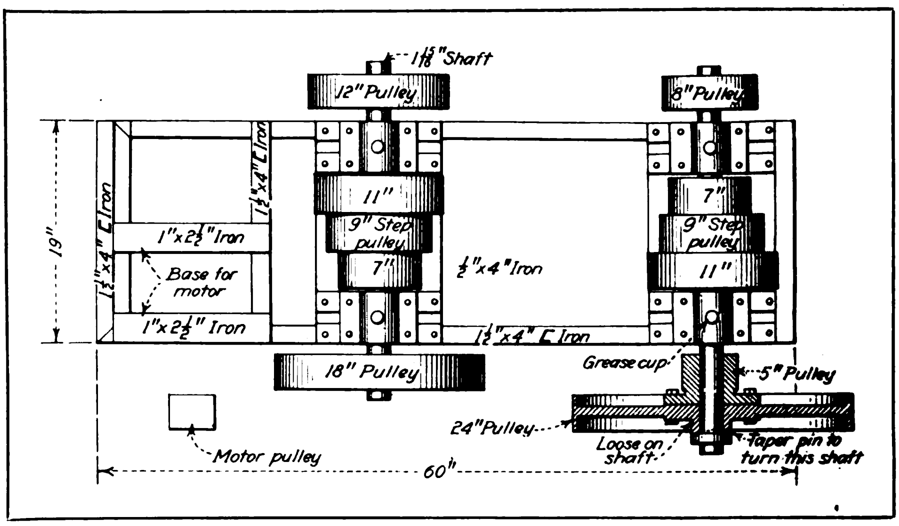
OFTEN it is necessary to drive a machine at a speed much lower than normal, when doing such jobs as banding armatures or grinding or turning slip rings or commutators of generators, rotary converters or large motors.

A motor with a combination of pulleys and countershafting mounted on skids in such manner that it can be moved to any job is very convenient for doing this work. The device shown in the illustration consists of two 9-in. step pulleys, an 8-in., a 12-in., and an 18-in. pulley and a combination 5-in. and 24-in. pulley on countershafts that are mounted on a channel-iron framework. At one end of the framework is a base plate for mounting a motor.

This speed reducer is arranged to give a large range of speeds. The motor is belted to the 24-in. pulley. The driven machine may be driven from the 5-in., 7-in., 8-in., 9-in., or 11-in. pulleys on the same shaft, or the 9-in. step pulley may be belted to the 9-in. step pulley on the countershaft and the desired speed obtained from the 12-in. or 18-in. pulley. Another combination is to drive the countershaft from the 8-in. pulley and drive the machine from the 18-in. pulley. By interchanging the 18-in., 12-in., and 8-in. pulleys other combinations may be obtained. The 24-in. pulley is arranged so that it may run loose on the shaft by removing a taper pin. In this case the motor drives the 24-in. pulley, the 18-in. pulley is driven from the 5-in. and the machine may be driven from the 12-in. pulley or by belting the step pulleys together the machine may be driven at different speeds from the 8-in. pulley.

Oxnard, Calif. W. W. PEASGOOD.

Two shafts fitted with pulleys of various sizes are mounted on a channel-iron framework, to make an easily portable outfit.

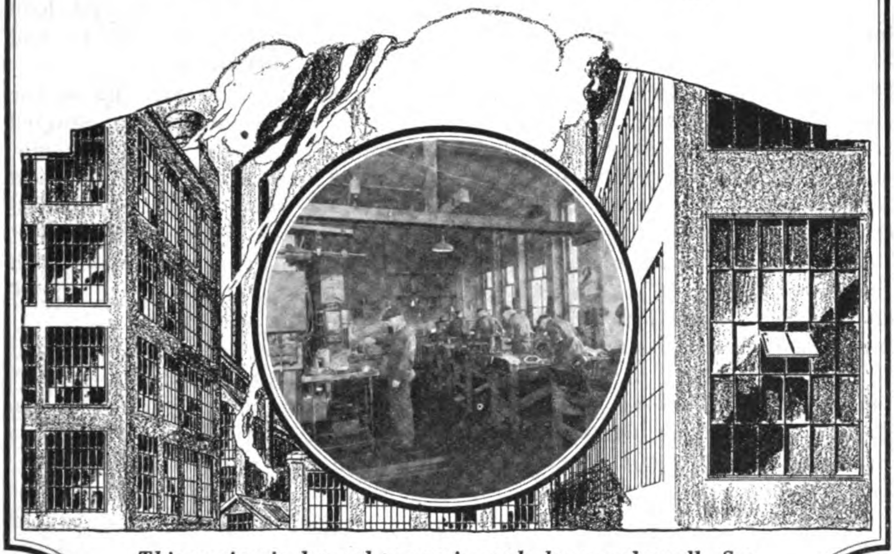


Loose Motor Shaft Cause of Insulation Chafing

CHAFING of insulation at the ends of the armature slots of a 15-hp. direct-current motor driving a drug mill, resulted several times in a grounded winding. After a long investigation this was found to be caused by a loose motor shaft. Before the cause of the chafing was determined the motor repeatedly gave trouble. The insulation was found to be cut in different slots, and although the motor was temporarily repaired by replacing the insulation, it finally had to be rewound. In rewinding, the coils were protected with extra layers of insulation, but as the trouble did not disappear the armature was at last taken from the frame for examination. After removing the coils the armature was placed in a lathe and its core was made stationary by means of a tool held in the tool post. Then it was noticed that on pulling the lathe belt the motor shaft revolved slightly in the core. When the core was taken off the shaft the keyways in the core spider and the shaft were found to be of different widths, allowing some rotation of the core on the shaft. As the load on the motor was one which increased and decreased suddenly, the coil leads connected to the commutator were worked back and forth in the slots as the load changed, and this chafed the insulation. By cutting a new keyway and using a larger key the trouble was entirely removed. L. A. FRANCIS.

Utica, N. Y.

In the Repair Shop



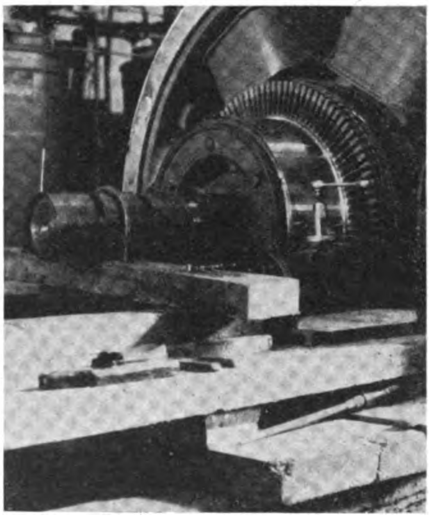
This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Novel Method of Turning Commutators of Large D. C. Machines

MANY plants which operate large d.c. machines do not have in their repair shops a lathe of sufficient size to accommodate the armature for the purpose of turning down the commutator. In such cases it is usually necessary to take the armature to some convenient machine shop or to purchase a special commutator grinding outfit to fit the machine. However, if the plant is situated in an isolated locality with machine shops a considerable distance away, it is necessary to resort to some other method of getting the commutators turned down when occasion arises.

The accompanying illustration shows how the writer solved this difficulty in turning down the commutator of a 40-kw. exciter driven by a water wheel. The armature was supported by wedges on the lower pole pieces and the end bell removed. The bearing was then removed from the housing and rigidly supported at the proper level and alignment by means of a U-bolt, as shown, the whole being mounted on a wooden frame which was securely nailed together. The supporting wedges were then removed and the commutator turned down by means of a portable slide rest mounted at the proper elevation on the wooden framework. Inasmuch as the unit is driven by a Pelton wheel, the speed could be adjusted to any value desired. To avoid vibration the speed was kept somewhat lower than for lathe turning and a fine, true job resulted.

In another plant the commutator of a 75-kw., d.c. generator was turned down in a similar manner. This unit is a motor-generator set driven by a 112-hp. motor and the whole is supported on only two bearings. As the speed is 1,200 r. p. m., it was not possible to use a motor for turning the armature. The shaft with the rotor and armature was accordingly entirely removed from the unit and rigidly mounted on a wooden platform and two bearing supports made up of rail ties. A 5-hp. back-geared motor was belted to it, the belt being slipped over the rotor as a pulley. This gave a speed to the armature of about 100 r.p.m., which, while somewhat slow, resulted in a good job being done. A slide rest was mounted in a similar manner to that shown in the illustration. FREDERICK KRUG.



The bearing was removed from the housing and held in place by a U-bolt in a heavy wooden framework which supported the commutator end of the armature.

Comerio Falls,
Bayamon, Porto Rico.

Some of the Details of How to Wind a Small Armature by Hand

THERE are many small direct-current motors which can be easily and cheaply rewound by hand. If formed coils can be purchased time can be saved by using them, but where they cannot be secured in a short enough time, hand winding is preferable. Some factories also wind these armatures by machine but not all repair shops have them.

This article will explain a method by which such armatures may be wound by hand. The simplest loop method of winding is employed and is suitable in most cases although where the end room is scarce it is sometimes necessary to use another type of hand winding, such as those described in the INDUSTRIAL ENGINEER for January and February, 1922. This discussion will deal with one particular armature which was rewound some time ago, but the same principles may be used on any small armature. The armature in question had sixteen slots and a 32-bar commutator. It was originally form wound but the form winding was to be replaced by a hand winding.

The armature was supported by the ends of the shaft and the wire bands for holding the coils in place were cut. Also the string band which held the leads down back of the commutator was removed. Then a good coil was selected to secure the data necessary for rewinding. Using a light chisel a mark was made on the side of each slot in which the coil lay. Following the leads of this coil down to the commutator, the bars to which the leads connected were marked. This armature had two commutator bars to each core slot and consequently had four leads coming out of each slot. Therefore all four leads were traced to the commutator. Two of these leads were on the surface while two others were covered with insulation. This was therefore cut away

and the position of the bottom leads was traced out. The four leads were found connected to three commutator bars. The first bar was connected to the beginning of the first coil; the second bar was connected to the ending of the first coil and the beginning of the second coil, and the third bar was connected to the ending of the second coil.

Sometimes the number of slots equals the number of bars in which case there would be only two leads from each slot. It is well to write down all data as it is taken from the armature. This can be kept and referred to when the armature is being rewound.

Next the top leads were pulled out of the commutator and the pitch of the coils was noted. Calling the slot which held one side of the coil No. 1, the other side was found to be in slot No. 9. Therefore the coil pitch was 1 and 9. Then the number of turns in several coils was counted and the wire size was measured. It was found that there were 22 turns in each coil and there were two coils in each slot, making 44 turns per slot. The wire was found to be 0.040 in. in diameter or No. 18 B. & S. gage.

The insulation was then cleaned from the core and the shaft. After the coils were removed the commutator was cleaned by passing a piece of hacksaw blade through the commutator slots or cups. The blade was ground thin to allow it to fit. A thin metal drift or other tool might be used for the purpose. The commutator was then tested for short circuits. A good commutator should stand at least 300 volts alternating current between bars and less than 110 volts should never be used for testing. If any short circuits are found they should be removed by scraping or digging between the bars. New pieces of mica should be forced in and held in place by shellac if any large holes are present in the insulation. Small holes can be filled with a mixture of litharge and glycerine mixed to a thick paste. This dries hard in a few hours and stays in place well.

If the shorts cannot be removed it will be necessary to take the commutator apart and re-insulate it or to put on a new commutator. If such is the case, before removing the commutator a mark should be made on the core to correspond to the marks on the commutator made before the coil leads were removed. If the commutator is later put back in another position the motor may not operate unless the brushes can be shifted enough to make up for the change.

The commutator was then tested for grounds. The voltage used on this test should be at least 1,000 volts. To save time in this test, a piece of bare wire was wrapped around the commutator so that it touched every bar. Then the test was made between this wire and the shaft.

Next the shaft was insulated with about four turns of varnished cambric. Fiber insulation was put on the ends of the core and the back of the commutator. All of this insulation was stuck in place with shellac. Varnish or insulating compound, but not glue, may be used for this purpose.

Next the first two slots were insulated with 0.010-in. fishpaper. Sometimes a layer of 0.009-in. fishpaper and a layer of 0.004-in. varnished cambric is used. The insulation was cut in strips so that the grain ran lengthwise of the slots. The strips were ¼ in. longer than the slots and wide enough to project 1 in. out of the slots on each side. Slots No. 1 and No. 9 were insulated for the first coil.

The spool of No. 18 double-cotton wire was supported near the armature so that it could turn freely as it unwound. The first turn was started in slot No. 1 allowing about 6 in. or 8 in. to project from the front of the slot. Then the wire was brought down close to the back end of the core to slot No. 9, through it and back to slot No. 1. This was continued until twenty-two turns were in place. Then the wire was doubled into a loop at the front end of slot No. 1. This loop was left about 6 in. long. This loop formed the ending of the first coil and the beginning of the second. A piece of cotton sleeving was slipped over this loop which was then bent out of the way.

It is good practice when placing two coils in a slot, as was done in this winding, to put a piece of insulating paper or varnished cambric over the first coil before putting in the second. Also in any hand winding it is well to place strips of varnished cambric underneath each coil before it is wound to insulate it from the preceding coils.

The second coil of twenty-two turns was next wound in the same slots, Nos. 1 and 9. Then a loop was made at the end of slot No. 1. Sleeving of a different color was slipped on this loop. The different color was used to distinguish this loop from the first loop. This was followed through the winding, the first loop in a slot having white sleeves and the second loop red sleeves.

Now the first slot was full so the next coil (the third coil) was started in slots Nos. 2 and 10. This slot was filled in a similar manner and the process was repeated until all slots were filled. The end of the last coil was then twisted together with the beginning of the first coil and a red sleeve was put on.

The coil leads were next connected to the commutator and the ends of the wire were cut off even with the front side of the risers. They were then soldered, using a small quantity of both flux and solder so that none would bridge from one bar to another or run down the back of the commutator. A hot iron was employed and this was held on each bar until the solder ran down to the bottom of the slot.

The insulating cells were cut off even with the top of the core and folded down in the slots on top of the coils. Then the banding wire was wrapped tight around the armature and soldered. The coils should extend a slight distance above the top of the slot so that the banding wire will hold them rigidly in place. If there is some empty space in the slots it would be well to fill this with fiber or paper before banding.

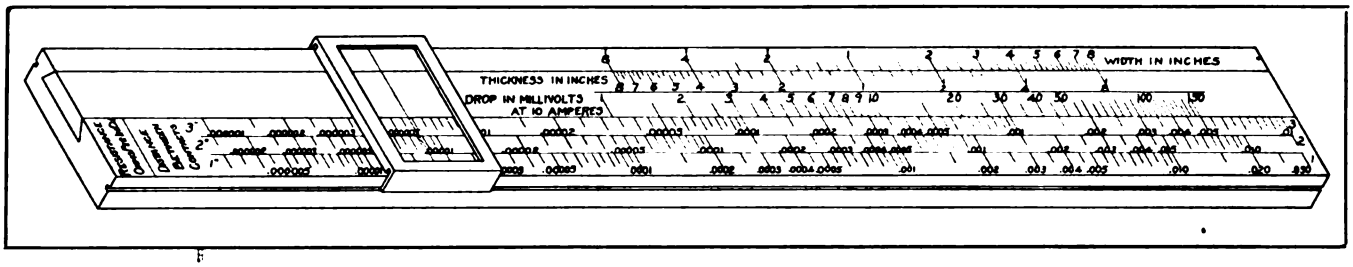
Next a band of cord was wound over the leads back of the commutator to hold them down. The armature was then dipped in air-drying varnish and allowed to dry. It probably would have been better to use baking varnish and to bake the armature for about eight hours at 180 deg. Fahr.

After this the commutator was turned, using a fine tool and taking a light cut, and finished with fine sandpaper. The commutator was examined for specks of copper between the bars and these were removed when found.

The armature was balanced by placing both ends of the shaft on smooth horizontal rails. A small unbalance was removed by adding solder to the bands on the lighter side.

The last thing to be done was to test the armature for grounds with 1,000 volts and for short circuits and open circuits by means of a milli-voltmeter. H. B. P.

Erie, Pa.



This slide rule is used for calculating the specific resistance of carbon blocks.

After the milli-volt drop over the block and the width, thickness and length of the block in inches have been determined, the width is set on the top scale of the rule, the thickness on the top scale of the slide, and the milli-volt drop on the bottom scale of the slide. The specific resistance is then read at the bottom of the rule.

Effect of Specific Resistance and Hardness on the Choice of Carbon Brushes

SPECIFIC resistance, as applied to carbon brushes, is a term used to denote the actual resistance in ohms of a cube of the brush material whose sides are 1 in. long. While specific resistance has some bearing on the magnitude of short-circuit currents on the brush face, its main effect is to increase or reduce short-circuit currents which might flow between the motor or generator brush studs of the same polarity, but of uneven spacing. Uniformity in resistance of the individual brushes on a machine is of greater importance than the actual value of that resistance, for inequalities throw an abnormal share of the load on the brushes of low resistance. Determining the specific resistance of the blocks of carbon or graphite, which are to be cut up into brushes, aids the manufacturer in keeping the product uniform.

The outfit illustrated is used for determining the specific resistance of carbon blocks which are to be cut up into brushes. The drop-of-potential method is used. A current of 10 amp. is passed through the block of carbon and the potential drop over a section of it is measured by means of the milli-voltmeter shown at the right of the illustration of the brush testing bench. The current, which is supplied from a 6-volt generator or storage battery, is adjusted by means of the rheostat at the top, on the right side of the vertical panel and its value read on the ammeter to the left of this rheostat. The terminal plates, between which the carbon piece to be tested is clamped, are seen in the center of the picture. These plates carry a number of spring-backed contact points insuring equalized current distribution over the ends of the carbon block. The milli-voltmeter terminals are two rows of similar spring-backed points bearing against the under side and across the full width of the carbon block under test. These may be seen between the main terminal plates in the illustration. One of these milli-voltmeter terminal strips is held in a T-slot and can be quickly placed at a distance of 1, 2, 3 or 4 in. from the other, as the size of the carbon plate may require.

The specific resistance of a given block of material is equal to the product of the resistance of the block in ohms times the width, times the thickness of the block in inches, divided by the length of the block in inches. Rapid calculation of the carbon resistance per inch cube is accomplished by means of the special slide rule, which is shown in another illustration. The scale for brush width is on the upper portion of the rule; that for brush thickness is on the upper edge of the slide; that for milli-voltmeter readings on the lower edge of the slide. The lower edge of the rule carries three scales indicating specific resistance directly for 1, 2 and 3 in. milli-voltmeter terminal centers. In testing several samples of the same width and thickness it is necessary to make but one setting of the slide, when the specific resistance can be read directly below the milli-voltmeter reading for each sample without further manipulation of the rule.

Test bench for determining hardness and specific resistance of carbon blocks, which are to be cut into brushes.

At the extreme left is shown the scleroscope which is used for determining the hardness. The device in the center holds the carbon block while a definite current is passed through it.

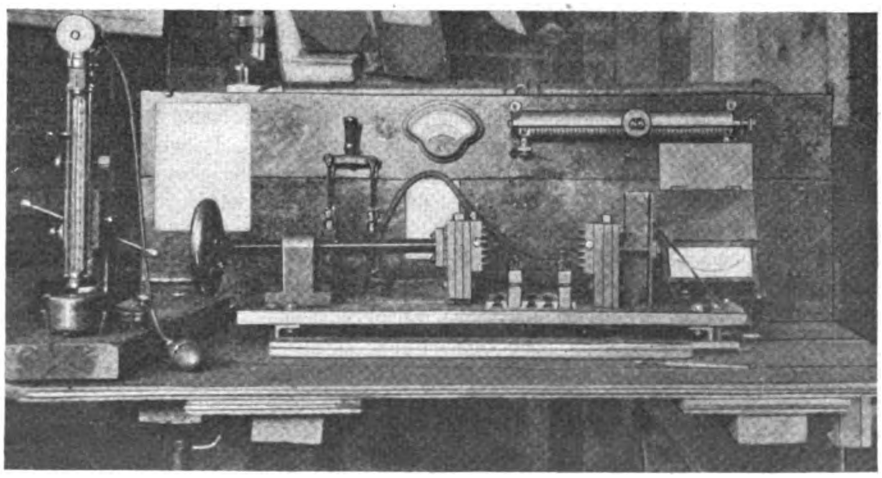
In carbon, graphite and carbon-graphite brushes the hardness of the brush is usually indicative of its strength. A hard brush is usually the strongest, but has a greater tendency to chip than a medium-hard brush. However, by the use of special processes of manufacture it is possible to make even the hardest brushes very tough.

The hardness of a brush is determined with a delicate instrument called a scleroscope. This is shown at the extreme left of the illustration of the test bench. In this instrument, a steel weight having a diamond point falls from a constant height and then rebounds up a graduated scale, the height of the rebound indicating the hardness.

Sales Manager,
Corliss Carbon Co.,
Bradford, Pa.
L. J. KERLIN.

Using Dynamite to Remove Small Locomotive Wheel Tires

THOSE who have to re-tire locomotive wheels know what a difficult job it is to heat the old tires enough to remove them from the wheels. When the tires are worn so badly that they cannot be turned or used again we find that the quickest and easiest method of removal is to



drill a hole in the tire from one side, allowing the drill to go within ½ in. or ¾ in. of the other side, and shoot it off with dynamite.

On electric locomotives the tires seem to become crystallized; so, although it is not absolutely necessary, better results can be obtained by the use of high-speed drills. We use a ⅝-in. or ¾-in. drill, depending on the thickness of the tire. As large a drill as possible should be used. Using a portable electric drill about 15 min. are required to drill a tire. If the locomotive has solid wheels the hole may be drilled anywhere around the tire; otherwise it is best to drill it over a spoke.

Because of the hardness of the metal it is necessary to cool the drill; oil can be used for this purpose, but we find that a stream of water gives just as good or better results.

After the hole is drilled we fill it with dynamite and place the cap on the outside, under a small handful of clay, which serves to hold the cap in place. When the charge has been shot it is only necessary to force in a tapered drift or punch which is slightly larger than the hole, in order to spread the tire, which can then be pulled off by hand.

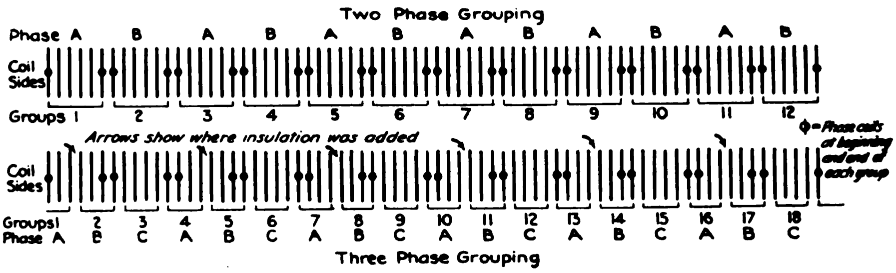
We operate forty-six locomotives, on which the average set of tires lasts about a year, and in changing dozens of tires we have not damaged a wheel. Also, by doing the job in this way we save over half of the time required to do the work by any other method. ELZA HERRMANN.

Middleport, Ohio.

Reconnecting Two-Phase Motor for Three-Phase

A TWO-PHASE motor which could be reconnected for three phases was handled recently by our shop. This was rather a rare case as ordinarily such a change cannot be made while retaining the same horsepower and speed. Usually it is necessary to rewind the motor.

In this case the motor had been bought as part of a second-hand motor-generator set. The motor was rated 60 hp., 220 volts, two-phase, 60 cycles, 1,200 r. p. m., 79 amp. The purchaser did not notice that the motor was two-phase until the set was installed and ready to run at his plant. We were called in at this point to determine whether the motor would have to be rewound or if it was possible to reconnect it to give full rating satisfactorily on



Old phase insulation was used when reconnecting motor.

When the two-phase winding shown in the upper part of the drawing was reconnected for three phases, as shown in the lower part, only six coils had to be re-insulated as phase coils. The old phase insulation served in twelve cases.

a three-phase, 220 volt power supply.

Removing the end bells and rotor we found that the stator winding consisted of seventy-two coils, each having seven turns of one 0.070 x 0.225-in. double-cotton-covered ribbon wire, pitch 1-and-9, and connected three-parallel with short jumpers. There were twelve groups of six coils in series per group.

In checking the possibility of reconnecting, the series-connection volts per phase for the same winding on three-phase, was figured first. This would be $(0.955 \div 0.905) \times 220 \times 3 \times 2 \div 3$, which equals 464.2 volts. In other words, if this motor were reconnected series-delta the three-phase line voltage would have to be 464.2. A two-parallel delta connection could be used and the voltage would be $464.2 \div 2$ or 232.1 volts.

In the above formula the value 0.955 is the distribution factor for three-phase and 0.905 is the corresponding two-phase factor; 220 is the two-phase line voltage; the first 3 is the number of parallel paths or circuits; 2 is the number of phases originally, and 3 is the final number of phases.

But the line voltage is 220 volts. Operating at 232.1 volts the horsepower would also be increased in the ratio of 0.955 to 0.905. Therefore the horsepower at 232.1 volts three-phase would be 63.3. Dropping down to 220 volts the horsepower would decrease as the square of the voltage. It would therefore be 57 hp. which is close enough to 60 hp. to give satisfaction.

By reconnecting the stator to two-parallel delta with eighteen groups of four coils in series per group the motor will operate as a normal three-phase motor at 60 hp.

The current in the coils will be approximately the same as in the original winding. In the original winding the line current was 79 amp. As there were three parallel paths per phase each path carried $(79 \div 3)$ amp. For a three-phase motor of the same horsepower and voltage the line current equals (the two-phase current $\times$ 2) $\div$ 1.73. Therefore under these conditions the line current would be $(79 \times 2) \div 1.73$, which equals 91.3. But the current in each leg of a delta-connected winding equals line current $\div$ 1.73. In this case it equals $(79 \times 2 \div 1.73) \div 1.73$ which equals $79 \times 2 \div 3$. But as there are two parallel paths in each phase the current in each coil equals $(79 \times 2 \div 3) \div 2$ which equals $79 \div 3$. This is the same current as flowed with the coils connected two-phase.

The current actually might differ slightly from this because (1) the distribution factor has been increased and (2) the motor is operating slightly under voltage at 220 volts. Increasing the distribution factor increases the efficiency in the same proportion and therefore the current at full load (60 hp.) at 232.1 volts would be decreased as 0.905 is to 0.955. The current per coil would be $(79 \div 3) \times (0.905 \div 0.955)$ which equals 24.95 amp. But as the voltage is less than 232.1 the motor will take more current for a load of 60 hp. It is reasonable to say that if the load is held at 60 hp. while the voltage is dropped from 232.1 to 220, the current will increase about in the proportion of 232.1 to 220. Therefore the current will be $24.95 \times 23.21 \div 220$ which equals 26.3 amp., which is the same as before the change.

By removing all the jumpers and regrouping the winding as shown in the lower part of the accompanying drawing the extra phase insulation between groups was preserved in all except six places. This final grouping resulted in only one phase coil between two groups, but this is sufficient for 220-volt operation. The six groups which required the addition of phase insulation are indicated by the arrows in the drawing.

Detroit, Mich. A. C. ROE.

Babbitt and Other Hanger Bearings

(Continued from page 231)

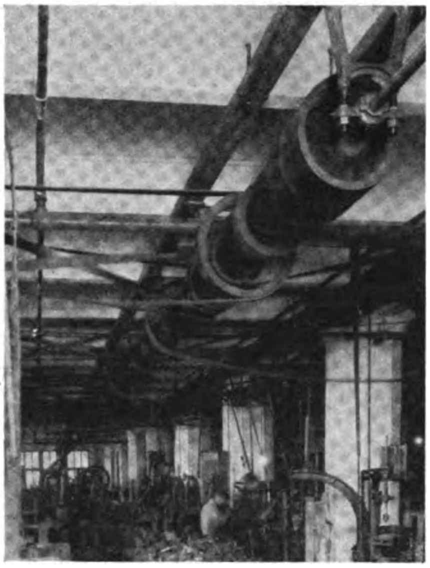
instead of a rigid support. This prevents breakage in case of misalignment. However, as a result, the shafting alignment is often neglected until the friction loss is heavy, in some cases using half of the full-load power consumption to drive the shaft alone.

Use of Roller and Ball Bearings for Power Transmission

Several manufacturers of ball and roller bearings have adopted them for use in lineshaft hangers. In most cases the manufacturers have designed special bearings of different types, each adapted to fit into a standard type of shaft hanger and simply replace the bearings which had been used. This enables the change-over in an installation to be made at low cost. Of these, roller bearings are split and so are the easiest to install. Ball bearings must be slipped on over the end of the shaft and in cases where flanged couplings or solid pulleys are used, or where the shaft is cut and scratched by set screws, their installation is more difficult.

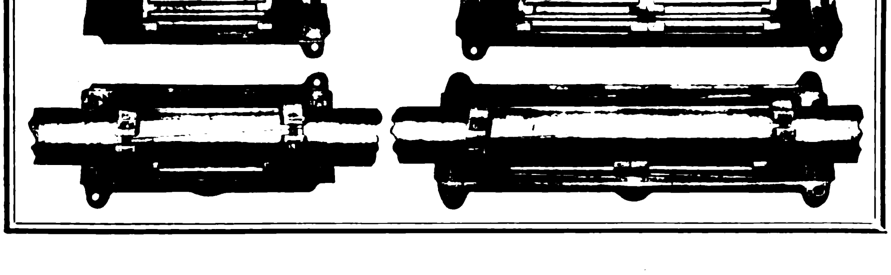
Where two sets of ball bearings are used in each bearing box the bearing is ordinarily known as the dumbbell pattern because of its shape. These are made by the manufacturer in various types each with slight alterations of the outside casing so that they will fit in any of the standard types of shaft hangers. Where one set of self-aligning ball bearings is used, a special shaft hanger is used in connection with it as it would be more difficult to fasten this in to the ordinary two- or four-point adjustment hanger.

The manufacturers of these various types of equipment show interesting figures as to the savings made by their installations. In addition to the decreased friction loss due to the better types of bearings, another important advantage is that they require considerably less attention for oiling, as it is sufficient to inspect them and change the oil two to four times a year, whereas other types of bearings should receive attention almost every day. As an occasional bearing is apt to be overlooked or neglected during the daily oiling operation, the ball- or roller-bearing types, due to the less frequent oiling periods, have an advantage in this respect and are less likely to cause trouble from that cause. The savings which may be made in many cases depend to a large extent upon the condition in which the shaft was before the change was made. A shaft in very bad condition could be improved by re-aligning alone.



An installation of ball-bearing hangers in a light manufacturing plant.

Some of the advantages claimed for ball bearings in power transmission lines are: Freedom from shut-downs and production losses, a decreased friction loss, better lubrication and lower maintenance costs.



Another type of roller bearing for use in shaft hanger.

This type of bearing is made with a single roller structure for use on line- and countershafts and with a double roller structure for heavy-duty bearing boxes, such as on main- or jack-shafts and with heavy belt pulls. These bearings are split and consist of three integral parts—the housing, the retainer and the high-carbon steel sleeve.

Editor's Note: Special acknowledgment is made to the following companies for assistance in furnishing information, data and illustrations for this and the other articles which appear on this subject: Allis-Chalmers Mfg. Co., Milwaukee, Wis.; American Pulley Co., Philadelphia, Pa.; Bond Foundry & Machine Co., Manheim, Pa.; H. W. Caldwell & Son Co., Chicago, Ill.; W. E. Caldwell Co., Louisville, Ky.; Chicago Pulley & Shafting Co., Chicago, Ill.; Dodge Manufacturing Co., Mishawaka, Ind.; The Fafnir Bearing Co., New Britain, Conn.; Falls Clutch & Machinery Co., Cuyahoga Falls, Ohio; Gund Manufacturing Co., La Crosse, Wis.; The Hill Clutch and Foundry Co., Cleveland, Ohio; Hyatt Roller Bearing Co., Newark, N. J.; W. A. Jones Foundry & Machine Co., Chicago, Ill.; Link-Belt Co., Chicago, Ill.; Medart Co., St. Louis, Mo.; Midwest Steel & Supply Co., Inc., New York, N. Y.; Royersford Foundry & Machine Co., Philadelphia, Pa.; Winfield H. Smith, Buffalo, N. Y.; Standard Pressed Steel Co., Jenkinstown, Pa.; The Skayef Ball Bearing Co., New York, N. Y.; The Transmission Ball Bearing Co., Buffalo, N. Y.; Weller Manufacturing Co., Chicago, Ill.; T. B. Wood's Sons Co., Chambersburg, Pa.

Changing Housings for Ball Bearings

(Continued from page 219)

However, it seems there are still points worthy of improvement. I will outline those which have occurred to us.

Troubles That May Develop and How They Can Be Corrected

Under the exceptionally severe hammering due to unbalanced load, the outer ball race may eventually wear into the cast-iron end bell. The exceptionally large oversize bearings and the cushioning effect of the grease packing have so far prevented this in our motors (three years' service on the oldest one) but if this wear does take place, it will become more and more rapid as the clearance increases. In this case, I would suggest altering the design to clamp the outer race, somewhat as the inner race is clamped on the shaft on the end opposite to the pulley end, and a change from ball bearings to some type of roller bearings, such as the Hoffman which are manufactured in sizes interchangeable with standard ball bearings. Perhaps ball bearings would give satisfactory life with the other race clamped in one position, especially

considering the greatly oversized bearings which we have applied, but it seems to be the concensus of opinion based on experience, that outer ball races should be free while roller bearing races with their greatly increased area of contact may be stationary if desired.

As previously described we have incorporated a thoroughly effective method of taking the shock from the bearing when driving on a coupling or pinion. So far we pull our pinions off with a "screw and yoke" puller. However, this requires constant watchfulness and instruction of millwrights and electricians to avoid abuse of the ball bearings caused by removing the pinion by driving in a couple of cold chisels between the bearing housing and the coupling or pinion. This method of removing a pinion is rough, but quick and effective. Since a whole gang of men is idle when one machine is out of service, time is a prime consideration. Actually we have removed couplings in this way. The oversize ball bearings stood the end thrust apparently without injury but this abuse of a plain radial type ball bearing is so flagrant that we do not recommend it for serious consideration. It would at first thought seem easy to apply, in a slightly modified form, the same design to the pulley-end bearing that we are using at the opposite end to take the shock of driving a pinion on. Actually this is not so simple. It would scarcely be practicable to hold all the axial dimensions of the parts of the motor to such close limits that the whole assembly, including the oil-tight joint, would total within 0.002 in. to 0.004 in. Furthermore the differences of expansion, as the motor warms up under load, between the shaft and the stator and end bells are likely to exceed such a maximum. In our design these differences in axial dimensions of parts, different thickness of paper and shellac, grease-tight joint, difference in expansion, and the like, are covered by a clearance of 0.125 in. left at *J*, on pages 217 and 218.

Now that we are equipped with patterns, gages and jigs for making the mechanical parts of these motors, we have found several applications where they are worth their necessarily high cost. In severe service on portable loading equipment in a coal storage yard at some distance from the main plant these sturdy motors which require greasing only once per year, reduce the necessary trips of an oiler or motor inspector from one per day to one per month. In gear drive applications requiring a metal pinion they behave admirably.

Changing Single-Phase Motors

(Continued from page 234)

in the table on page 232 for the proper voltage and multiply it by 0.57. Then multiply this answer by the circ. mil allowance given in Table I for the required horsepower rating. In the case just figured (8.1 × .57 × 600) equals 4.617 × 600 or 2,770.2, which is close enough.

The next step is to find the coil pitch. This equals [1 and 1 + (48 ÷ 4) × .8] equals (1 and 1 + 12 × .8) equals 1 and 10.6, or 1-and-10.

The method outlined above can be used in the same manner for two-phase machines. All unnecessary calculations have been eliminated, the purpose being to enable the average electrician to develop a motor that will run and carry its rated load satisfactorily and with reasonable efficiency.

The rotor can be used as it is, but see that all joints between end-rings and bars make good contact. The cutout switch used on the single-phase winding should be removed.

Works of Eastman Kodak Company

(Continued from page 215)

for unloading and development. This routine originated the famous phrase: "You press the button, we do the rest." This used a roll of paper film. In 1889 the present cellulose, transparent film base was realized. The kodak had created amateur photography for the world and the Eastman industry at Rochester was organized to take care of the demand created by its own inventions.

But the industrial demands of the amateur were soon dwarfed by a new and unforeseen demand which had been created as a direct result of these film discoveries. Eastman's achievements came at a time when Edison was in the midst of his motion picture experiments. A transparent flexible film, combining good photographic quality with tensile strength was necessary to the success of the Edison invention. The Eastman film filled the Edison need and motion pictures were made possible. It was not, however, until 1895 that motion picture film was sold for other than experimental purposes. Today 15,000 motion picture houses in the United States require from sixty million to one hundred million feet of motion picture film at every performance.

In 1880, under the firm name of George Eastman, was begun the manufacture of dry plates. In 1891, a year or two after the kodak and film photography were born, a single building with 27,500 sq. ft. of floor space supplied the factory and office needs of the company. Today four large plants are maintained in Rochester alone, for the manufacture of various types of cameras, lenses, photographic papers and film.

Kodak Park, the largest of these, is devoted exclusively to the manufacture of film and other sensitized products. It is a tract of 230 acres situated in the northwesterly section of the city. The capacity of Kodak Park in motion picture film alone is approximately one hundred million feet per month or, roughly 225,000 miles a year. About five million pounds of cotton are used annually in the manufacture of Eastman film, and for the sensitizing of Eastman products over three tons of pure silver bullion, or one-twelfth of all the silver mined in the United States are consumed every week. The thousands of tons of acids per month for nitrating this cotton and silver, are also manufactured at the Park, as are the raw papers, gelatines, wood-paper and fibre boxes, cartons, tin containers, film spools and wood parts for cameras.

The right arm of the photographic industry is the laboratory, and Kodak Park boasts one of the most completely equipped and best staffed laboratories in the industrial world. In addition to testing laboratories, X-ray rooms and studios, the building is equipped with an independent plant for the manufacture of photographic material on such a scale that the results can be practically applied in the manufacturing departments. Here are also made photographic materials for scientific work for which, of course, there is little or no commercial demand.

In addition to Kodak Park, three other plants in the city and a sixteen-story office building are required for the various activities of the company. One of these plants is devoted to the manufacture of kodaks and

"Brownies," another to studio, professional, aerial and laboratory photographic equipment, and still another to the manufacture of lenses.

In addition to these, plants are maintained in Toronto, Canada; Harrow, England; Melbourne, Australia; and distributing branches in all the more important countries.

Improving Wiring Around Machinery

(Continued from page 224)

The National Electrical Code states that all wires larger than No. 6 gage should be stranded. However, for industrial work it will be found preferable to have all wires stranded where there is a possibility of vibration. Quite a number of large works use stranded wire exclusively for light and power wiring and use nothing smaller than No. 12 for this service. Since varnished-cambric insulated wire has about 20 per cent more carrying capacity than rubber-covered, it is being widely used in locations that are permanently dry. In places where there is a possibility of dampness, rubber-covered wire should be used. In locations that are excessively hot, flame-proof, asbestos-covered or slow-burning insulated wire should be used, since rubber insulation will not withstand the effects of high temperature or oil. In a permanently damp or wet location a lead-sheath cable must be used.

The value of inclosing various pieces of equipment has been pointed out both from the standpoint of safety and continuity of operation. One thing should be remembered however about inclosing-cabinets. If they are used, they should be locked, for otherwise unauthorized persons will open them, or they will be left open, thus destroying their effectiveness. Locking them also prevents the operator from using them as a convenient catch-all for lunch, clothing, tools or oily gloves.

Wiring around machinery from the standpoints of convenience of operation, ease of construction, and cost will be discussed in a later issue.

EDITOR'S NOTE: Special acknowledgment is made to the Brunswick-Kroeschell Co., Chicago, Ill., for some of the pictures which show the excellent wiring in its factory, and to C. V. Putnam of the Reliance Electric & Engineering Co., Cleveland, Ohio, for suggestions and assistance in obtaining many of the illustrations used.

Practical Books

For Your Personal Library

Every man who aspires to larger responsibilities should build up a professional library. Copies of these books may be obtained from the publishers mentioned.

The Story of Bakelite—By John Kimberly Mumford. Published by Robert L. Stillson Company, 461 Eighth Avenue, New York, N. Y., 80 pages, illustrated.

This book tells in an interesting, rather than a scientific way, some of the story of the discovery, manufacture and application of Bakelite to the many and various applications in the arts and industries, in commerce and in warfare.

* * * *

Principles of Alternating Currents—By Robert R. Lawrence, associate professor of electrical engineering, Massachusetts Institute of Technology. Published by the McGraw-Hill Book Company, Inc., 370 Seventh Avenue, New York City. First edition, 432 pages, price $4.

This book was written to be used as a college textbook and treats the subject in a thorough but theoretical and technical manner.

* * * *

Principles of Electric Motors and Control—By Gordon Fox, electrical engineer, Freyn, Brassert & Company, member A. I. S. E. E., member A. I. E. E. Published by McGraw-Hill Book Company, 370 Seventh Avenue, New York City, 492 pages, price, $3.50.

In this book is given a clear practical treatment of the principles, construction and performance of electric motors and controllers for those interested in the selection, application, purchase and operation of such equipment.

Most existing texts dealing with electric motors and controllers treat the subject primarily from the design viewpoint. This book tells the entire story of motor and control equipment from the point of view of the user. The author from his many years of experience as an electrical engineer in industrial fields, and especially from his close connection with the electrical side of the steel industry is particularly fitted to write on the subject from this viewpoint.

Very simple, easy-to-understand explanations are given of the underlying principles governing the action of both d. c. and a. c. motors. The characteristics of each type of motor are explained as well as the reasons for the differences in characteristics. The industrial applications of each type of motor are shown in such a manner as to make easy an intelligent application of the different types to the job in hand.

Controllers are treated in detail from the simple manual controller to the complicated crane hoist automatic control using dynamic braking. Such topics as plugging, dynamic braking, regeneration and jam resistors are discussed in detail. Ten pages are devoted to the determination of the total amount and number of steps required for the starting and accelerating resistance of a motor.

The book is profusely illustrated with pictures of the various kinds of equipment, diagrams showing how the apparatus works, curves giving the characteristics and complete connection diagrams showing how to connect up the various motors and controllers. Sequence and simplified schematic diagrams are also given for the more complicated automatic controllers, showing the sequence of contactors and the function of each in the operation of the controller as a unit.

Three chapters that are of particular interest are those on the operation of motors in parallel and series, on the use of flywheels in the application of electric power, and on electric motor braking.

* * * *

Mechanics of the Gasoline Engine—By H. A. Huebotter, M. E., Member S. A. E. Published by McGraw-Hill Book Company, 370 Seventh avenue, New York City, 313 pages, price $4.00.

In this book the principles of the mechanics of materials are applied to the solution of general problems of gasoline engine design in such a way as to illustrate the procedure and simplify the work for specific cases. Representative units of engines of various kinds are illustrated and in many cases analyzed.

* * * *

Pulverized and Colloidal Fuel—By J. Y. Dunn, Consulting Chemist, Newcastle-Upon-Tyne, England, published by The Van Nostrand Company, 8 Warren Street, New York City. 193 pages illustrated, price $6.

Reference is made in the introduction of this book to the use of powdered fuel in America and in France and the statement made that England has been relatively slow in adopting it. The book contains a review of the use of powdered fuel, accompanied by descriptions of the different processes for preparing it and the general conditions surrounding combustion and furnace operation. Frequent reference is made to articles in the Journal of the American Society of Mechanical Engineers, the Engineer and Engineering of London, the General Electric Review, Proceedings of the Engineering Society of Pennsylvania and to other published literature on the subject. Credit is also given to the following companies for furnishing information: The Powdered Fuel Plant Company, the Fuller Engineering Company, the Raymond Bros. Engineering Company, the Sturtevant Engineering Company, the Underfeed Stoker Company, Messrs. Simon-Carves and to Lindon W. L. Bates on the subject of colloidal fuel.

Trade Literature

You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Lewellen Manufacturing Company, Columbus, Ind.—Bulletin 250 is a supplementary catalog covering the automatic and hand-operated remote control, Lewellen variable-speed transmission devices. Several installations are illustrated and described.

The Obenchain-Boyer Company, Logansport, Ind.—A series of bulletins describes the several types of Boyer fire apparatus for industrial and small town fire protection. Some of the various pieces of equipment illustrated and described are: 45-gal. single- and double-tank, portable, hand-drawn, chemical fire engines, and several types of complete fire apparatus with triple combination of pumping engine, chemical tank and hose equipment, together with ladders, lanterns and portable 2½ gal. chemical extinguishers and other necessary apparatus mounted on Ford trucks and other chassis.

Carr Fastener Company, Boston, 39, Mass.—A bulletin entitled "Better Lubrication for All Machinery" illustrates the construction of the Dot high-pressure lubricator and its application to the lubrication of various types of machinery. With this, grease or oil are forced into a bearing under high pressure created by screwing down on a cylinder.

The Republic Rubber Corp., Youngstown, Ohio.—A 32-page booklet shows a number of installations of Republic rubber- and friction-surfaced canvas belts for conveyor and power transmission purposes. Some of the topics discussed are: Points to be considered in the purchase of conveyor belting, care of conveyor belts, oil-well belts, elevator belting, splicing belts, condition and care of belting, and rules for making belting calculations.

The Thompson Electric Company, 226 St. Clair Avenue, Cleveland, Ohio—A small folder entitled, "The Lamp-Cleaner's Helper," describes the disconnecting hanger of the underslung model which is used to lower overhead lamps so that they may be cleaned easily, and more frequently.

Eldredge Solenoid Manufacturing Company, Springfield, Mass.—A new bulletin describes the Eldredge solenoid relays which are used for automatically controlling and lighting safety traffic lamps from the main power station simultaneously with the series street lights.

The William Cramp and Sons Ship and Engine Building Company, Philadelphia, Pa.—Folders describe Cramp's babbitt metals which are made in several grades of tin-base babbitts. Other folders describe cored bars for bushings which are furnished either in Parson's white brass or in Cramp's special bearing bronze.

Chicago Belting Company, 110 North Green Street, Chicago, Ill.—Every industrial man having supervision of the installation and maintenance of the factory belting will find the 32-page booklet, "Making Leather Belts Endless," very useful in suggesting what the belt manufacturer has found the most satisfactory method of cementing the ends of the belt on the job instead of lacing. This contains not only a description and list of the tools and material required for this work but also shows by reproductions of photographs and sketches exactly how these tools are to be used. In describing the various cements, as with the tools, particular stress is laid on when, where and how each is to be used.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—A small booklet entitled "Electric Heat" takes up industrial applications of electric heat and shows how it has been applied in an automobile factory, for japanning, for preventing water tanks from freezing, for core baking ovens, and as space heaters. This is issued as a serial publication occasionally and anyone desiring it may be put on the mailing list.

DeLaval Steam Turbine Company, Trenton, N. J.—Catalog D describes the construction and operation of centrifugal pumps and shows a number of their uses. A pamphlet entitled "Tests on Motor-Driven Pumps" shows the results of several tests made on motor-driven centrifugal pumps in different locations and under various operating conditions.

New Departure Manufacturing Company, Bristol, Conn.—A number of bulletins on New Departure ball bearings and their universal application which contain special engineering information are issued at frequent intervals to show practical mountings for New Departure ball bearings and to aid in securing correct installations, operating efficiency and economical service. A recent bulletin, for example, No. 13-FE, is entitled "Ball Bearing Mounting Practice."

Buffalo Wire Works Company, 316-332 Terrance Avenue, Buffalo, N. Y.—Folder 68 illustrates the various wire and sheet-metal lockers manufactured for use in factories, schools and other places having large numbers of employees.

H. C. Grohn and Sons, 6248 South Sangamon Street, Chicago, Ill.—Literature describes the "Grohn Electro Heatometer" which is an open-circuit signal system to automatically register on an annunciator or by the ringing of a bell, any rise in temperature above a desired point. The instrument has a wide range of adjustment, ranging from 0 to 1,800 degrees and can be applied to indicate heating in bearings, over-heating of motors or generators, heating in coal piles or in closed rooms where perishable material or explosives are stored, and for indicating the maximum permissible temperature in dry kilns, bake ovens, or other processing operations.

The Martindale Electric Company, 11709 Detroit Avenue, Cleveland, Ohio—A folder entitled "Imperial" commutator stones gives directions for ordering, standard sizes, the ten "Imperial" commandments, advantages of using "Imperial" commutator stones and directions for using "Imperial" commutator stones.

Truscon Steel Company, Detroit, Mich.—The "Truscon metal lath data book" gives specifications, details, tables and practical information on Trucson "Hy-Rib" metal lath and shows how it can be used for partitions, ceilings and walls, roofs and floors for new construction and additions to industrial buildings.

Acme Electric Heating Company, 1217 Washington Street, Boston, Mass.—The Acme melting ladle is used to keep babbitt, tin, lead, solder and other similar metals in liquid state by a non-oxidizing electric heating unit built into the ladle. The unit is portable and is connected by a detachable three-heat plug. The ladle is mounted with right and left-hand pouring spouts.

American Pipe Bending Machine Company, 3739 Pearl Street, Boston, Mass.—A group of circulars describes the use of the Wonder pipe, tubing, and solid-bar benders which are used for bending pipe or bars cold. The hand-operated machine will bend pipe from the smaller sizes up to about 4 in., while the motor-operated machines will handle pipe up to 8 in. in diameter. Some of these sizes will bend cold bars up to 3 in. in diameter. These machines will bend the pipe cold to a right angle bend in either standard weight or thin-gaged material without crushing or weakening. Circulars show what sizes of pipe may be handled by each of the models and also the radius to which they may be bent.

Glow-Brite Company, 1006 Rockefeller Building, Cleveland, Ohio—A circular describes the use of Glow-Brite, which is a special preparation for cleaning skylights and side windows. It is claimed that it will remove the oldest and hardest accumulations of dirt, grime, carbon or rust scale without injury to paint, putty or sash.

Foamite-Childs Corporation, Turner Street, Utica, N. Y.—A sixteen-page booklet entitled, "The Essentials of Self-Protection Against Fire," discusses the various classes of fires and the types of extinguishers and shows by a table the various characteristics of different types of fire extinguishers and the solutions which they contain. This table discusses the use of foam, soda-and-acid, anti-freezing (calcium-chloride), and tetrachloride fire extinguishers and shows to which type of fire each is best adapted.

In Two Sections—Section One

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

JUNE, 1924

McGraw-Hill Co., Inc. Chicago. Ill.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 82 Chicago, June, 1924 **Number 6**

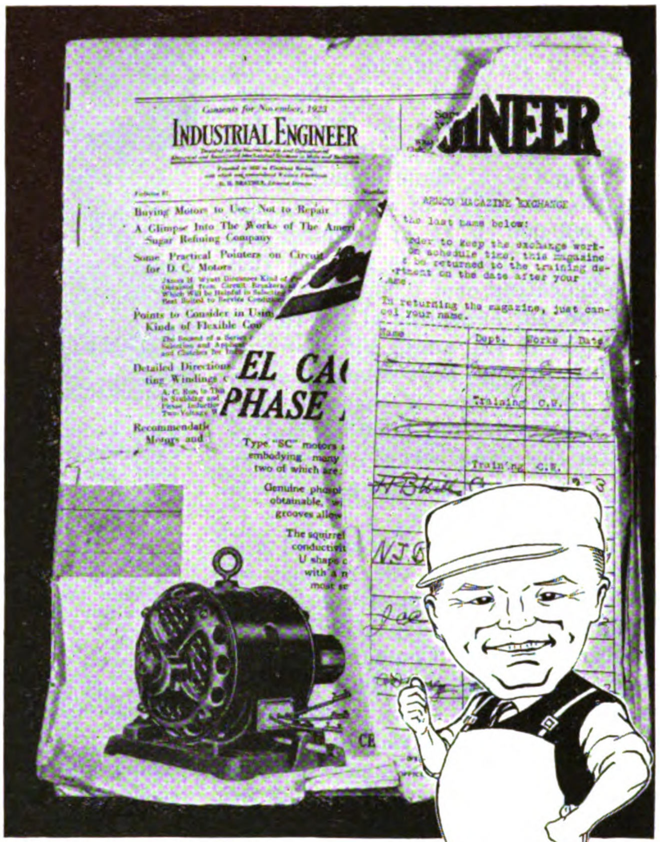
Do They Read It? Well—Judge for Yourself

This Is a Copy of Our Paper That Has Gone the Rounds in the Plant of the American Rolling Mill Company

WHILE I count only as one on the staff of men who are trying to make this paper the best of its kind—I'm telling you right here that I am proud of this photograph, and it means a lot to me. It's a copy of an issue that has gone the rounds in the plant of the American Rolling Mill Company and is one of twenty-one others that have traveled the same course. Every page looks just as bad as the cover; torn up, thumb marked, and penciled here and there. These are the kinds of marks I understand for I know the thinking of men who carry a hunk of waste for a handkerchief and leave the mark of honest toil on white paper; men who have a job that bluff and inexperience cannot hold and that calls for head-scratching, arguments and sometimes disputes as to the best, quickest and cheapest way of doing things. While these men know what they are doing they are always glad to find a better way. Such men are the backbone of quality in American products and I feel proud of having traveled their road; when I have an opportunity to shake their greasy hands and talk to them, I'm right back home.

But this is a little off the point I want to make here. All practical papers that get down deep into the details of the work of men who are doing things are read, studied and kept for reference. But some are read more than others when the management of the works finds a way to make sure that the operating brains of their plants have a chance to see those papers that deal with the operating problems that are the everyday problems in the plant.

Such a plan has been formed by the American Rolling Mill Company and they have a reading table where their men can see all papers they are interested in, and after these papers have been on that table one week any particular one will be sent to the man for his own use if he will indicate a desire to see it. This is a good idea and it works, for the company advises that practical papers are now circulating among nearly 200 key men in its plants at Middletown, Ohio, Zanesville, Ohio and Ashland, Ky., and that



several subscriptions are necessary to get them around before they are out of date.

It may be that you know of some other plan like this or an improvement on it. If so, drop me a line explaining your scheme so that we can pass it along and let others benefit thereby.

For INDUSTRIAL ENGINEER I can say that it's your paper in every sense and you can help us to make it just what you like to have it by your suggestions and requests for the information that you need most. But it's the discussions on material published and suggestions for additional data or facts that we like best for then we know that you read it—not just thumb it through—and we feel that we have a part in the job you are doing.

Practical Pete

A Glimpse Into the

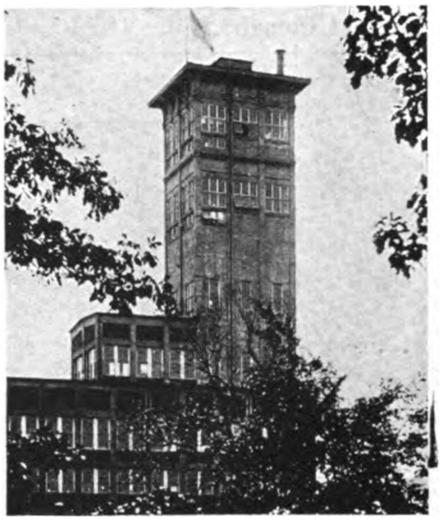
Works of The Winchester-Simmons Company

Which has added the manufacture of high-grade cutlery, tools and fishing tackle to its line of arms and ammunition, to utilize additional factory space erected to take care of demands for war production.

SOME IDEA of the extent of the manufacturing operations at the Winchester plant may be obtained from the diversity of its power equipment. The power plant is one of the largest industrial power plants in New England. In this plant is generated all of the electrical energy used in the factory for power, light and tempering.

The gas plant alone manufactures 600,000,000 cu. ft. of water gas and 1,700,000,000 cu. ft. of producer gas annually. This gas is used as fuel for generating over 9,000 hp. and, in addition, for annealing at the rolling mills and in the auger bit shop and as fuel in the heat-treating shop. Over 100,000 tons of coal are used each year to fire the 7,500-hp. boilers and for the manufacture of producer gas. The gas and steam plant has a capacity of 16,375 hp.

The manufacture of arms and ammunition, which is the product of the Winchester Repeating Arms Company, a subsidiary of The Winchester-Simmons Company, represents two widely separated lines of manufacture, but each requires a high degree of accuracy and skill. The value of these produced in 1923 was $25,000,000, practically all of which was used for sporting purposes. A repeating rifle or shotgun contains in addition to the carefully forged, bored and straightened barrel the intricate operating mechanism to load and eject the ammunition. All of this requires highly skilled handwork in its manufacture. This equipment must be reliable, as a sportsman's life may sometimes depend upon it. For this reason a gun often becomes very personal to its user.



This concrete structure is devoted exclusively to the manufacture of lead shot.

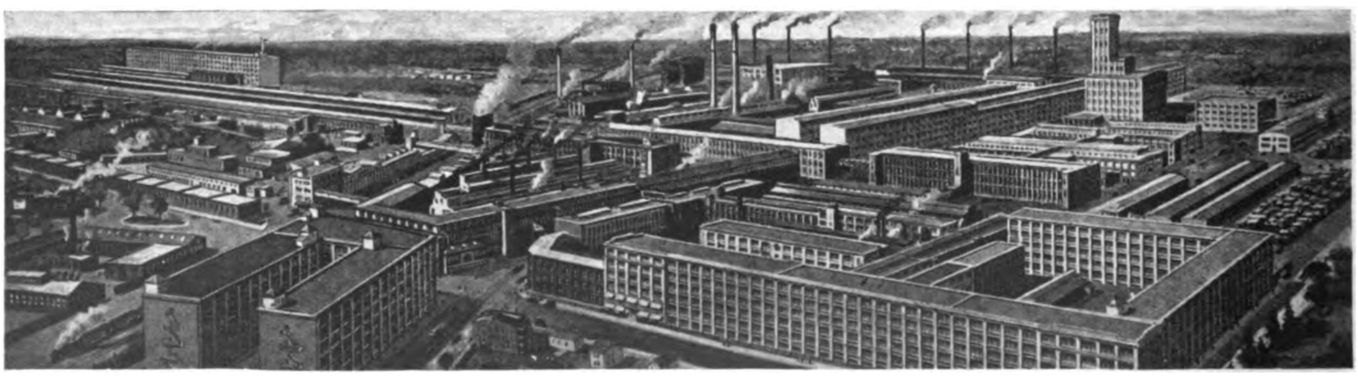
All materials are mixed and melted according to special formula at the top of the tower, nearly 225 ft. high. The molten metal is poured through a screen and after a drop of 190 ft., during which the pellets have been formed, the shot lands in a tank of water, is cooled and then cleaned and scoured. The shot is then automatically carried to selecting machines where the pellets are cascaded over a series of thirteen inclined glass plates which eliminate those having slight irregularities of size, finish or shape.

The Winchester Repeating Arms Company, which was the parent organization, was organized in 1866 with eighteen employees. This was a reorganization of The Volcanic Arms Company, established in 1855, which was in 1856 reorganized as the New Haven Arms Company. When the United States entered the World War, the force had grown to 6,000 employees and the plant occupied sixty acres. During the World War the Winchester plant was easily turned into war production and as the organization was skilled in this work, both plant and equipment were expanded to provide increased production. At the signing of the armistice, about 22,000 employees were operating 21,000 machines driven by 2,000 motors and were producing 2,500 military rifles and 2,000,000 cartridges daily in addition to the large number of bayonets, cannon primers and other war equipment, including Browning machine guns and rifles.

To use the extra plant and equipment it was decided to begin the manufacture of a line of cutlery and tools which, like arms, would have a strong personal appeal as they would be actually used by the purchaser. In addition, many of the manufacturing operations—forging, grinding, tempering and others—are required in both lines of production.

The present plant at New Haven, Conn., is devoted to the manufacture of arms, ammunition and some of the new hardware.

The original Winchester factory employed eighteen men. The present factory covers eighty-one acres of ground, and contains 3,500,000 sq. ft. of factory floor space. Over 22,000 were employed during the World War in the manufacture of arms and ammunition. At the signing of the armistice part of this space was turned over to the manufacture of cutlery, tools, fishing tackle, flashlights and batteries and other similar hardware.



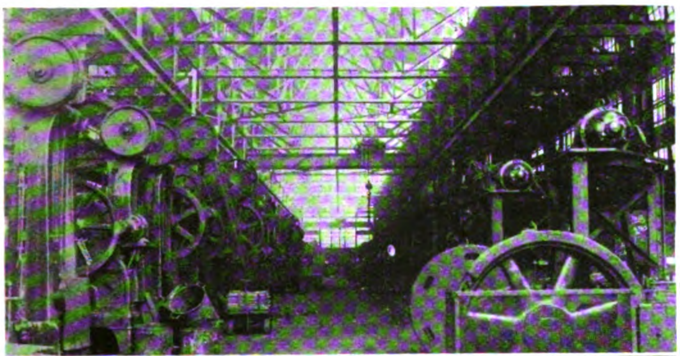
Steps in the manufacture of knives and of cartridges.

The semi-automatic machines (above) are used for wet grinding of knife blades. In addition, the knives are dry-ground and polished. With the exception of steel, all of the products used in the manufacture of the various lines of sporting goods and hardware supplied by this company, are processed from the raw materials in its own shop. For this, it has a modern rolling mill (upper right) which is used to roll down the ingots of nickel, copper and zinc, after these materials are mixed according to the specific formula and cast in strips for rolling. These products are used in the manufacture of cartridges, fishing tackle, pocket-knife lining, reels and other products. The illustration at the right shows the pneumatic tube for transporting powder from storage to the cartridge loading room.

Also, a flashlight battery, for example, requires a drawn zinc tube—an operation similar to the drawing of brass cartridge shells. Present day production requires about 1,500 tons of copper, 5,000 tons of steel and 8,500 tons of lead in addition to large quantities of zinc and nickel yearly.

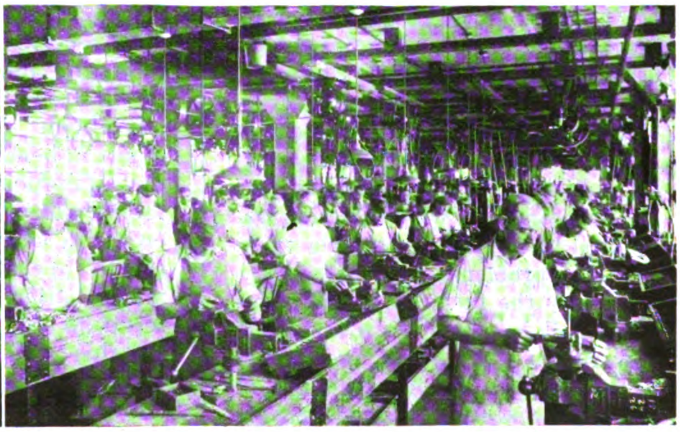
To get distribution, the Simmons Hardware Company was co-ordinated in the organization. The Winchester-Simmons Company is selling its new product exclusively to a group of about 6,000 hardware stores in the United States. Other lines, such as builders' and other miscellaneous ordinary hardware required, are purchased. The addition of this new line of hardware, such as cutlery, tools, fishing tackle and the like, has added fifty-three different lines of merchandise, including over 2,000 new items which contain more than 22,000 different components and require hundreds of thousands of fixtures, tools and gages for their manufacture. The extent of the tool department which manufactures all the tools, fixtures and gages used in the manufacture of these various products, indicates one of the big problems in adding a new line to an industry. The tool department occupies 75,000 sq. ft. and employs over 1,000 mechanics. The most important and the most accurate, of course, are the tools and gages required in the manufacture of gun parts.

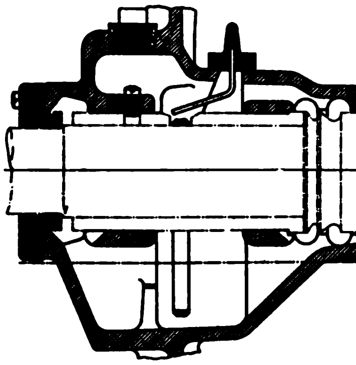
The plant has a good record for continuity of service as over 3,500 employees have a record of over five years service and of these about 300 have been with the company over twenty-five years.



A few examples of the varieties of work in the manufacture of guns at the New Haven plant.

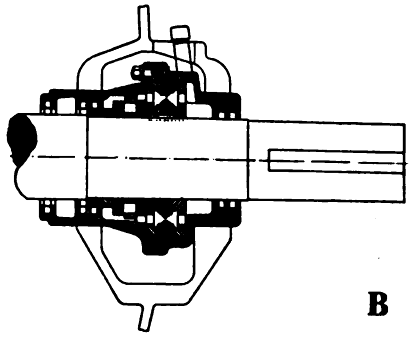
In the forge and hammer shop (left) the guns, rifles, axes, hatchets, knives, scissors, chisels and other forged tools are formed. While some of the hardware equipment can be ground or machined to a finish, many of the parts in gun and rifle manufacture must be carefully filed to shape by hand as shown in the illustration below. This is slow, careful work as each part must be absolutely accurate or made so that it will work perfectly. Another important step is the straightening of the rifle barrel, (lower left), as accuracy in shooting depends upon it.





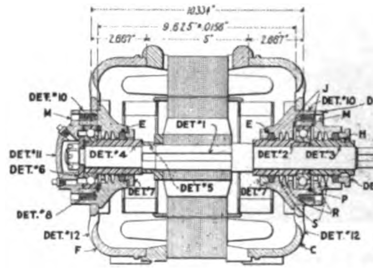
A

This improved design of sleeve bearing with leakproof devices to prevent escape of oil at high speeds, was described in an article in the March issue. In that article the improvements which have been made in sleeve bearings, with their advantages and pointers on their maintenance and care, were described.



B

How these roller bearings were installed in mill-type motors was described in an article in the April issue. The advantages resulting from the use of roller bearings and the troubles eliminated by using them in place of the sleeve bearings originally furnished with the motors, were set forth in detail.



C

The use of ball bearings mounted in dustproof housings, to eliminate the troubles encountered with sleeve bearings in motors operating in a foundry, was described in an article in the May issue. In that article complete details of the design of the housing and the method of installing the bearings were given.

Viewpoints of Manufacturers on

Possible Improvements in Bearing Service

And the Things to Consider in Connection with the Use of Sleeve, Ball and Roller Designs Under Varying Conditions in Mill and Factory Operation

By G. A. VAN BRUNT
Managing Editor, Industrial Engineer.

FOR MANY YEARS, plain or sleeve bearings were the only type in use and they have served their purpose well. However, with the development of modern, high-speed equipment and a more insistent demand that friction and other power losses be cut to a minimum, the attention of engineers and designers was directed to the problem of designing a form of bearing which would be superior in most, if not all, respects to the plain bearing. In particular it was desired to produce a bearing in which friction was reduced to the lowest possible value. That the problem is not new is evidenced by the fact that patents covering ball bearings were taken out upwards of sixty years ago. These bearings were crude compared to those of present-day design and are of theoretical rather than practical interest. The widespread, commercial use of anti-friction bearings has come about within the past twenty-five years, roughly.

INSPECTION AND CARE of bearings is an important feature of every maintenance crew's job. In some classes of service, for example, in cement mills, bearings probably receive more attention than any other mechanical, or electrical, element of the equipment used. Improvements in bearing service from the standpoint of reduced maintenance cost and increase in length of life under severe operating conditions are a matter of everyday interest to all operating men. In this article details are given showing what bearing manufacturers are doing to help in solving this problem.

The most severe of all tests, the test of service, has weeded out various imperfect designs so that at the present time there are two broad types of anti-friction bearings in general use: ball bearings and roller bearings. The various designs of ball and roller bearings with directions for their installation were described in the September 1922 issue of INDUSTRIAL ENGINEER. When properly applied, both of these classes of bearings have given good service.

A great deal of development work has also been done on plain bearings, both in the way of improving the qualities of the metal from which the bearings are made and in improvements in the design of the bearing and its housing.

The user of bearings has, therefore, three types of bearings to choose from: plain, ball and roller bearings. In order to present to the readers of INDUSTRIAL ENGINEER the advantages and possibilities of each of these types of bearings from the standpoint of meeting the wide range of service conditions in industrial work, these points have been discussed in articles that have appeared in recent issues. For example, in the March issue, R. Pruger discussed some of the troubles which have been experienced with sleeve bearings and showed how these have been minimized or entirely overcome by correct design of the bearing and by proper oiling and care. In his conclusion, he pointed out that when correct principles are applied to the design of sleeve bearings,

with high standards of manufacture and maintenance, these bearings possess many advantages from the standpoint of economy.

In the April issue, L. J. Hess outlined his experience in the application and operation of 300 sets of roller bearings on mill-type motors in steel mill service. After the successful solution of certain mechanical problems involved in the installation of roller bearings in sleeve-bearing motors his experience showed that roller bearings possess the following advantages:

(1) Electrical repairs to commutators and windings are greatly reduced because at least 50 per cent of these troubles start from oil and grease working their way onto the commutator and front V-ring. With roller bearings the grease is entirely confined within the bearing shell. (2) Commutator wear is materially reduced because there is no jumping of the armature due to loose bearings with its tendency to cause flashing and consequent flat spots. The shafts are longer lived because the only wear on them is in the keyways. (3) The fact that the armature is held constantly in the center of the magnetic field helps to make the current distribution uniform, thereby relieving the equalizer connections of abnormal duty. (4) Broken bands due to rubbing are unknown. (5) Pinions are kept accurately in mesh and crowding of the teeth with constant strain and vibration is eliminated. (6) Expense of inspection is somewhat reduced due to better commutation, and less attention is required for lubrication. (7) The cost of lubricants is reduced to an almost negligible figure as the bearings consume practically no grease. (8) Because of the reduction in repairs it follows that not only are labor and loss of time in the mills during armature changes reduced, but also the delay time charged against the electricians.

Robert W. Drake in the May issue showed how relief from serious bearing trouble was sought and found in the application of ball bearings in small motors. These motors operated molding machines in a foundry and were subjected to excessive amounts of sand and grit. Under these circumstances the sleeve bearings with which these motors were equipped had an average life of six weeks, although many failed in a week or less. The loss in production delays and the cost of frequent replacements of bearings were intolerably high and after a good deal of experimenting ball bearings enclosed in a dustproof housing were installed in a total of about forty motors, with very satisfactory results. There have been no bearing failures and little or no maintenance expense. Some of these bearings have run for three years without regreasing.

Under proper conditions sleeve, roller or ball bearings will give satisfactory service. The selection of the type of bearing to be used for a given application must be predicated on a careful study of the service conditions and requirements of the drive in question. Compared with the others, each of these types of bearings has advantages and disadvantages. From the standpoint of their application to motors, the advantages and disadvantages of the anti-friction bearings were summarized as follows by A. M. MacCutcheon in a paper presented before the Association of Iron and Steel Electrical Engineers:

Advantages

(1) Absence of oil. By various steel mill electrical engineers, it has been estimated that the presence of oil is responsible for 60 to 90 per cent of their motor troubles, causing injury to the insulation, shorting of commutator bars, gumming of commutators, causing collection of dust and a general unsightly condition. The lubricant is more easily retained in a ball or roller bearing than in a sleeve bearing.

(2) Reduction in maintenance cost. Much less frequent attention need be given to the lubrication of a ball or roller bearing. The weight of the evidence received from the users of anti-friction bearing motors is to the effect that failure of bearings is very much less frequent than on oil-ring bearing motors.

(3) Reduced wear of the bearing, resulting in much less frequent renewal of the bearings due to the lowering of the rotor and the consequent decreased air gap at the bottom. This consideration is of particular importance on induction motors with their small air gaps.

(4) Increased efficiency. A record was presented of a test on a 3-hp., 1,500-r.p.m. induction motor. Three motors were used, one equipped with ring-oiler bearings, another with waste-packed bearings and a third with ball bearings. The test showed the following efficiency:

Ring-oiling bearings	81½ per cent
Waste packed	80½ per cent
Ball bearing	84 per cent

(5) A considerably decreased torque is necessary at starting. In the case of an oil-ring bearing, sufficient torque must be applied to break the contact of the shaft on the bearing metal before the oil film is established.

(6) Anti-friction bearings make possible a considerable reduction in the overall length and in the weight of the end housing. Babbitted bearings are usually designed with the bearing length two and one-half or three times the diameter of the shaft, whereas the length of the ball bearings is usually not over one-third of the shaft diameter. A ball bearing manufacturer has advised that a tabulation of standard motor sizes proved that the overall length can be reduced on an average of 15 to 20 per cent by using ball bearings.

(7) The information received from the railroads, the Government and the steel mills which have experimented with anti-friction bearings, indicates that these bearings have been successful and this experience should certainly be classed as a strong argument for the use of such bearings.

Disadvantages

(1) Cost. The first cost of the motor will be greater and two lines of motors will have to be manufactured as long as the users of motors are not unanimous in their opinion. If the user changes to the anti-friction type of bearing, it will be necessary for him to carry two lines of spares until all of the oil-ring bearing motors have worn out or been replaced.

(2) Difficulty in making replacements. It does not seem that it will ever be possible to replace a ball bearing as easily as an oil-ring bearing. To secure proper operation, it is necessary that the inner race be tight on the shaft, which prevents its easy removal. For steel mill operation, it may be necessary to carry complete armature with bearings assembled. This would certainly not be justified unless the reduction in the number of bearing troubles more than compensated for this extra expense.

(3) The care which is necessary in successfully mounting anti-friction bearings and assembling the armature in the frame. The oil-ring type of bearing does not require the careful assembly needful with an anti-friction bearing.

(4) It is essential to very carefully protect anti-friction bearings in handling and installation. This is

readily recognized as a disadvantage in the steel plants.

(5) The workman in the steel mill is unfamiliar with the mounting of anti-friction bearings and the assembly of such motors. This must be charged up as a disadvantage until such time as the average worker becomes sufficiently familiar with this type of motor to be able to disassemble it without any difficulty or detailed instruction.

(6) In cases of armature grounding, current may pass through the balls or rollers and the races, causing pitting; in extreme cases, actually fusing race to balls or rolls.

(7) Under emergency conditions where a spare bearing is not available, the oil-ring type of bearing may be babbitted or cast by any reasonably good workman. This is not true of the anti-friction type.

(8) The strongest argument against the use of anti-friction bearings or any other device is the fact that it has not been thoroughly proven under actual operating conditions. Whether or not the anti-friction bearing will stand up as well as oil-ring bearings under shock and unusual load conditions, has not yet been conclusively demonstrated. Until the case for the anti-friction bearings has been firmly established, they must be recognized as being on trial.

The following comments have been received from manufacturers of bearing metals, and anti-friction bearings in response to an invitation by INDUSTRIAL ENGINEER to give their suggestions on possible improvements in bearing operation and the points to consider when installing these bearings.

Comments That Have Been Received From Manufacturers of Bearings

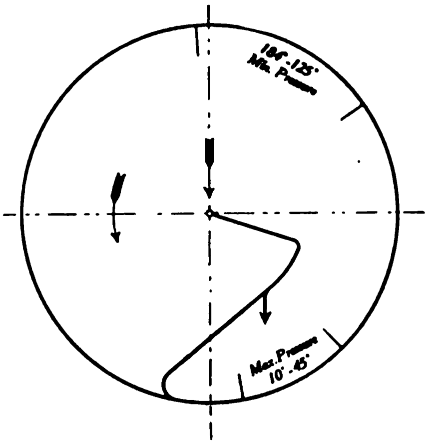
Relating to Improvements in Bearing Operation and Practical Points to Consider When Installing Sleeve and Anti-Friction Bearings in Equipment

C. H. Bierbaum, Vice-President and Consulting Engineer, Lumen Bearing Co., Buffalo, N. Y.: The relative merits of sliding-surface and rolling-surface bearings have been very ably discussed in two recent numbers of INDUSTRIAL ENGINEER. Mr. R. Pruger, in the March issue, very ably presented the sliding-surface or sleeve bearing, and Mr. L. J. Hess, in the April issue, the rolling-surface, or ball and roller bearings; each one discussing his topic from an intensely practical viewpoint. The reading of the two articles puts one into the compromising frame of mind in which the young judge found himself after his first hearing, when he decided "you both got the case." In fact they both have. There is a field in which each kind is best.

The very nature of the production of all the rolling-surface bearings required that they should receive more initial thought and study than the apparently simple forms of sliding-surface bearings; in fact the production of the former, from the beginning, has been a specialized one, whereas the latter have been "made by almost anyone, from almost anything, for almost everything."

There is no sharp dividing line between the respective fields for the two kinds of bearings; this is brought out clearly by the fact that different users often disagree in their preference for one or the other when considering specific bearing requirements, and also for the reason that we find users changing from one to the other, and after years of trial again returning to their first choice.

It is, therefore, evident that a lack of general dissemination of the technical knowledge relating to sliding-surface bearings, has, and is, constantly mitigating against the proper use of the same. The first real scientific study on the subject of bearings was begun by Tower, forty years ago. It was he who first demonstrated that a film of oil could carry the load of a bearing without having metallic contact between the bearing surfaces. He showed that certain definite and immutable laws exist which govern the forming and the maintaining of an oil film. It is, therefore, evident that unless a machine designer or a mechanic fitting up a bearing understands these laws, he is working in the dark, and



Movement of center line of journal and position of points of minimum and maximum pressure on oil film in bearing when journal is rotated and load gradually applied.

his results will be erratic and questionable.

These pioneer and subsequent studies have shown that for proper lubrication a definite amount of clearance or space around the journal must be provided as a space in which the oil film should form; that without this space it is impossible for the film to form. It has also been shown that if the bearing is not a complete cylinder the advance edge of the same should be chamfered or rounded off in order to permit the film to form. An increase of speed increases the thickness of oil film if temperature and other conditions remain constant and provided that sufficient space or clearance has been allowed. The use of an oil of high viscosity requires that more clearance be provided for a proper film to form. A common rule to follow for ordinary machinery is that of allowing a clearance of 0.001 in. plus an additional 0.001 for every inch of diameter of journal. The load carrying capacity of a bearing is not necessarily proportionate to its projected area, since a large unbroken area is capable of supporting a greater pressure per unit area than a smaller one. The function of oil grooves is to supply and distribute the oil to the bearing; they should not be excessive. Oil grooves can be made a positive detriment to a bearing by being excessive or in that part of the bearing in which the film is subjected to maximum pressure, in which case they become effective drains for carrying off the oil film.

The accompanying illustration is an interesting and profitable study of the behavior of the journal and bearing and that of its oil film. To begin with, let us assume that we have a journal 3 in. in diameter. According to the foregoing rule of clearances that would have a total clearance of 0.004. in. That is, the center point of the journal will then have enough freedom to be able to describe a circle 0.004 in. in diameter, and at the same time be able to assume any position within this circle. In the diagram let the diameter of the outer circle be equal to 0.004 in. We will then be able to plot all the movements of the center of the journal within this circle. After lubrication rotate the journal in the direction of the curved arrow, without having any load upon the same (not even its own weight); the center of the journal will then assume a position in the center of the circle, having an oil film of even thickness throughout its entire circumference. Now, if we continue the rotation of the journal and gradually apply a load in the direction of the vertical arrow, the center point of the journal will move along a line making an angle of 72 deg. with the vertical, as the load is gradually increased. This line may be called the load line, which the center of the journal follows to a distance equal to one-fourth the amount of clearance which, in this case, would be 0.001 in. Here the oil film is ruptured, and the maximum carrying capacity of the bearing will have been reached.

When a bearing is at rest, the loaded journal will be in metallic contact with the bearing at the lower point of its vertical diameter. As rotation begins, rolling of the journal upon the bearing occurs and continues to a point called the angle of repose, where slipping begins and when an oil film begins to form, at the same time. From here it

follows the curved line and then assumes a position upon the load line corresponding to the amount of load which it carries.

Very important features brought out in this diagram, are the location of the arcs where maximum and minimum pressure occur upon the oil film. While a load is being gradually applied, the center point of the journal moves along the load line, a maximum pressure begins to develop at a point 10 deg. from the foot of the vertical diameter(measuring all degrees in a counter-clockwise direction). With an increasing application of load upon the journal, this point of maximum pressure gradually shifts to a point of 45 deg., beginning with zero, to that necessary for the rupture of the oil film. In the same manner and at the same time a minimum pressure is being developed at a point of 184 deg., and as the load is increased, this point of minimum pressure gradually shifts to 125 deg., and there constitutes the minimum pressure at the time of oil film rupture; its value changing from atmospheric pressure at first to a negative pressure or distinct suction.

This study clearly shows where the oil grooves **should be placed,** and where they **should not be placed** for best service conditions.

Donald L. Colwell, Metallurgist, Stewart Mfg. Corp., Chicago, Ill.: One commonly neglected cause of a great many sleeve bearing troubles is the choice of the wrong bearing metal. Much attention is paid to the design of the bearing, with particular emphasis on means of lubrication, and many and various are the devices for providing and maintaining a continuous oil film between the journal and the sleeve.

When it is possible to design a bearing that will automatically keep a continuous oil film between the bearing and the shaft without undue loss of oil, the problems of the engineer are greatly simplified. Such a bearing, however, is not often found. When such a bearing is found, it is subject to the human element; for its oil cup must not run dry. It is necessary, therefore, to construct the bearing of a material that will cause the minimum amount of damage if the lubrication does fail.

Let us consider a simple sleeve bearing supporting a steel shaft. In the first place, no matter how carefully the shaft is ground and the bearing fitted, when the shaft first revolves in the sleeves it will rest on a few "high spots," and bridge over the intervening areas. This causes an unduly high load to be placed on the high spots of the bearing metal, and usually the oil film at these points is broken. This continues until the shaft has either pressed these high spots down, or worn them away to the lower levels of the bearing. If the bearing material is plastic enough, they will be pressed into place and the shaft will rest uniformly on the whole bearing. If the bearing material is not plastic, the high spots will remain until they are worn down by the shaft, and often the shaft itself is worn somewhat by the process. This introduces fine particles of bearing metal, and sometimes steel, into the oil, with ruinous effect on its lubricating value. It is necessary, therefore, to make the bearing as plastic as possible so that the high spots in the new bearing will be squeezed down, rather than worn away.

After this bearing is properly "worn in," it will function nicely as long as the oil film separates it from the shaft. However, if the lubrication is faulty and the oil film broken there is metallic contact between the revolving piece of steel and bearing metal; that is, a steel surface is rubbing against another metallic surface with a greater or less velocity. This causes a certain amount of energy which revolves the shaft to be used in overcoming the friction; this energy reappears in the form of heat. The amount of energy used in overcoming friction depends on the friction developed and this, in turn, depends in part on the co-efficient of friction of the bearing material. It is advisable, then, to secure a bearing metal with a low co-efficient of friction.

The heat developing from the friction can do harm in many ways, but we will neglect the harm it might do to certain forms of apparatus and consider only the effect of high bearing temperature on the bearing itself, or the shaft. It must be remembered that in addition to these limitations, the maximum temperature allowable is limited by the application of the bearing in the apparatus. High bearing temperature can harm the shaft only if high enough to draw the temper, if the shaft is hardened, but it might seriously soften the bearing and lower its load bearing qualities. The table shows the effect of temperature upon the hardness of several grades of white bearing metal, including both tin- and lead-base alloys. It is advisable, therefore, to secure a bearing material which will not soften under heat.

It is seen, then, that the following considerations should influence the selection of a sleeve bearing material, after the requirements of physical strength, machinability, etc., have been met: (1) The material should be plastic enough to fit itself to the shaft without excessive wear. (2) It should have a low co-efficient of friction. (3) It should withstand heat without serious softening. (4) It should also be hard enough to resist excessive wear.

In general, there are three types of bearing metal in use today; the white bearing metals, the bronzes, and the copper-lead metals. The white metals are usually either lead or tin base, although zinc-base metals have been used. The lead base metals are hardened by the addition of antimony, tin, or copper, or any two of these, or all three. The strength and hardness of the metal depend on the amount of hardener added, but the following analysis, that of specification No. 14 of the Society of Automotive Engineers illustrates the class:

METAL	PER CENT.
Tin	9.25 to 10.15
Antimony	14.00 to 16.00
Lead (max.)	76.00
Copper	0.50
Arsenic (max.)	0.20
Zinc and Aluminum	None

The tin-base metals are also hardened by antimony and copper and sometimes lead is added. The following S. A. E. specifications, No. 11 and No. 12 are representative of the tin-base bearing metals:

METAL	SPEC. No. 11 PER CENT.	SPEC. No. 12 PER CENT.
Antimony	6.00 to 7.50	9.50 to 11.50
Copper	5.00 to 6.50	2.25 to 3.75
Tin (min.)	86.00	59.50
Lead (max.)	0.35	26.00
Iron (max.)	0.08	0.08
Bismuth (max.)	0.08	0.08
Arsenic (max.)	0.10	....
Zinc and Aluminum	None	None

Specification No. 11 is representative of the so-called genuine babbitt metals, first used by Isaac Babbitt, and is a high-grade bearing metal. The copper and antimony are often varied considerably from these figures for different uses.

The microstructure of a genuine babbitt metal is shown in the upper portion of Fig. 1. As the molten metal cools, the antimony crystallizes in the cube-shaped crystals of composition

Physical Properties of Some White Bearing Metals at Temperatures Above Normal

BEARING METAL	PROPERTY	TEMPERATURE 25° C 77° F	50° C 122° F	75° C 167° F	100° C 212° F
S.A.E. Spec. No. 11	Brinell hardness	22.3	18.2	14.8	11.3
Copper 5.75%, Antimony 6.75%	Yield point	5,750 lb. per sq. in.	5,000	4,250	3,350
Tin 87.50%	Ultimate strength	16,425 lb. per sq. in.	12,175	10,100	7,725
S.A.E. Spec. No. 12, Copper 3.00%	Brinell hardness	22.4	15.8	11.3	7.5
Antimony 10.50%, Lead 25.00%	Yield point	4,700 lb. per sq. in.	3,650	2,900	2,150
Tin 61.50%	Ultimate strength	13,685 lb. per sq. in.	10,035	7,845	6,045
S.A.E. Spec. No. 13	Brinell hardness	19.7	16.8	11.4	8.2
Tin 5.00%	Yield point	3,750 lb. per sq. in.	2,650	2,250	1,550
Antimony 10.00%, Lead 85.00%	Ultimate strength	15,020 lb. per sq. in.	11,275	7,920	4,770

NOTE—These values are taken from Bureau of Standards Technologic Paper No. 188, by Freeman and Woodward.

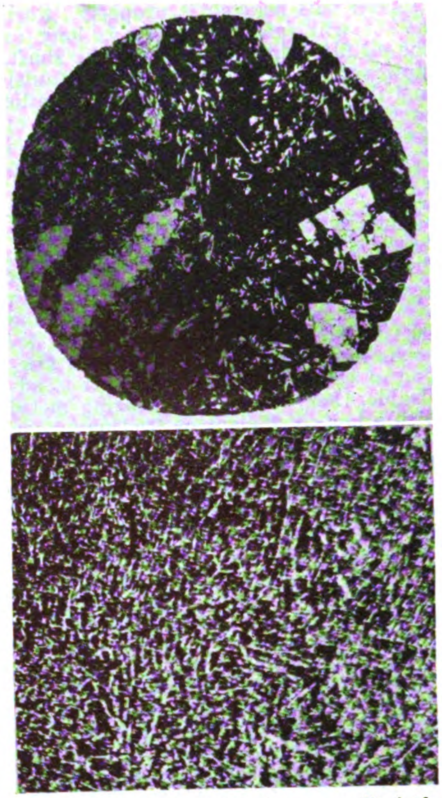


Fig. 1 — Microstructure of two types of bearing metals.

Above, structure of genuine babbitt metal which was cooled slowly to favor the development of large crystals. The large, cube-shaped crystals are an alloy of tin and antimony. The copper crystallizes out in pointed or hook-shaped crystals which are composed of, roughly, three parts of copper and one part of tin. The crystals are shown here as they appear when magnified 80 diameters. The lower photograph shows the structure of a copper-lead bearing metal. The long, tree-like crystals, which appear white in the photograph, are composed of practically pure copper. The material, shown as dark areas, between the copper crystals is mostly lead. This photograph was taken under a magnification of 20 diameters.

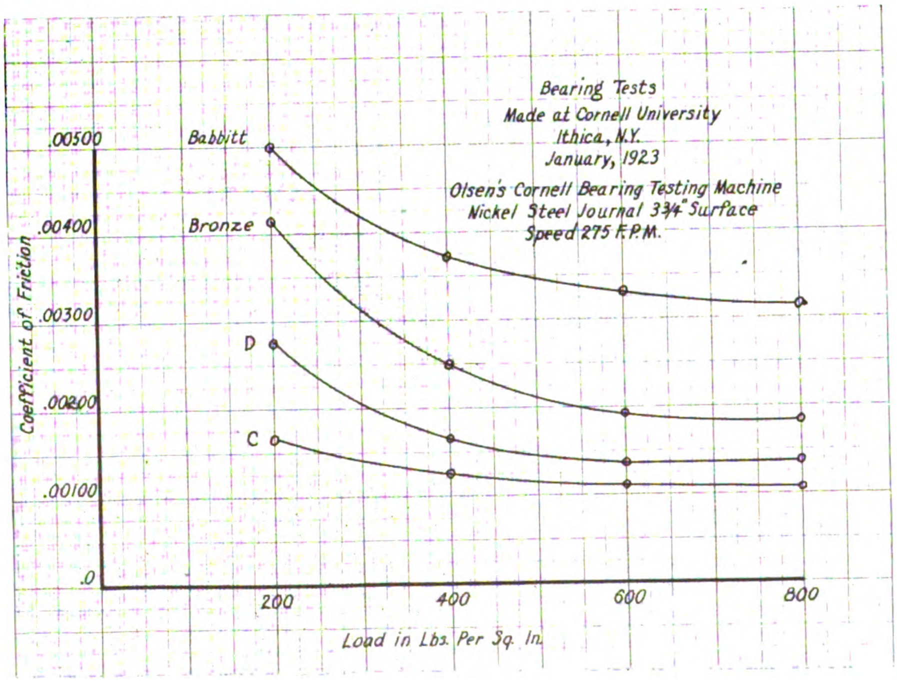
SnSb. The copper crystallizes out in the hooks and spines of composition Cu_3 Sn. The size of these crystals depends on the rate of cooling and it has been found that the metal with the rapidly-cooled, smaller crystals gives a superior bearing. That is one great advantage of die-cast babbitt bearings. The lead-base bearing metals (often incorrectly called babbitts) develop a similar structure.

It is seen, therefore, that the white bearing metals are composed of hard crystals imbedded in a soft matrix. The hard crystals carry the load and resist the wear, while the soft matrix has a fairly low co-efficient of friction and is plastic enough to easily adjust itself to the shaft. However, the effect of temperature on the white metals is disastrous, as is shown in the table. In fact the white bearing metals will usually melt at some temperature between 350 deg. F. and 500 deg. F.

Because of their superior strength, the bronzes are very largely used for bearings where the loads are heavy. They are not plastic and will not adjust themselves to the shaft. They are hard enough to resist wear, but at the same time this hardness is often ruinous to the shaft, particularly when the bearing is overheated. Cut and scored journals are often found when bronze bearings are used. The bearing bronzes consist of a copper base with varying amounts of tin, zinc and lead, and sometimes a little phosphorus, manganese, or aluminum. Strictly speaking they are not bearing metals, but are metals used for bearings simply because they are strong enough to do the work.

Fig. 2—Co-efficient of friction of tin-base babbitt, commercial bronze and two grades of copper-lead bearing metal.

The bearings were all tested on the same machine. The babbitt contained 84 per cent of tin, 7 per cent of copper and 9 per cent of antimony. The bronze contained 86 per cent of copper, 9 per cent of tin, 3 per cent of zinc and 2 per cent of lead. Curve *C* represents a copper-lead bearing metal containing 65 per cent of copper and 35 per cent of lead. *D* represents a similar metal containing 80 per cent of copper and 20 per cent of lead.



The third type of bearing metal is the result of the attempts to improve the bearing qualities of the bronzes by increasing the lead content, with the production of a copper-lead bearing metal. Some of the bronzes contain 10 per cent or even 15 per cent of lead, but it has been found commercially impracticable to add more than 15 per cent of lead because of liquation and segregation. A special process has recently been developed, however, for producing a copper-lead metal with the lead content as high as 60 per cent with 40 per cent of copper. The structure of such a metal is shown in the lower part of Fig. 1.

The copper-lead bearing metal developed by this process may contain from 20 per cent to 60 per cent of lead. The strength and hardness decrease as the lead increases. A consideration of the microstructure will show why this is so. As the molten mixture solidifies, the copper crystallizes out first in substantially pure form, and gives the dendritic, or tree-like crystals shown in Fig. 1. The lead eutectic remains molten long after the copper skeleton has solidified, and when it does freeze it fills in the interstices and cushions the copper. Thus the bearing consists of a skeleton or network of copper cushioned by lead. The strength of the alloy is simply the strength of the copper skeleton and, of course, it is not so strong as bronze. From 60 per cent to 80 per cent of copper, however, gives a bearing of higher strength than the same bearing in white metal. It is also possible to strengthen the copper to a certain degree by the addition of a small amount of tin or some other metal.

From a bearing standpoint the copper-lead metal combines the advantage of both bronzes and white metals. The copper skeleton can be made hard enough and strong enough to carry the load and resist the wear. The lead cushion makes it plastic enough to conform itself to the shaft, and at the same time cuts the amount of friction because of the lower co-efficient of friction of lead. A comparative study of the friction of four bearings is shown in Fig. 2. The bearings were all tested on the same machine. The babbitt is genuine, containing 84 per cent of tin, 7 per cent of copper, and 9 per cent of antimony. The bronze is a commercial bearing bronze containing about 9 per cent of tin, 2 per cent of lead, 3 per cent of zinc, and the balance copper. Curve (*C*) is that of a metal containing 65 per cent of copper and 35 per cent of lead; (*D*) contains 80 per cent of copper and 20 per cent of lead. The curve shows the superiority of the copper-lead metal over both bronze and babbitt. The copper-lead metal will also stand up under high temperatures, because of the high melting point. Copper-lead bearings have been run dry until the shaft was red hot, a temperature of 1,300 deg. F., without harm to either the shaft or the bearing.

D. E. Batesole, Asst. Engineer Manager, The Norma Company of America, New York, N. Y.: The articles which have appeared in the past few issues of INDUSTRIAL ENGINEER are indeed very interesting and should be of considerable help to everyone connected with the maintenance of plant equipment. Those particular portions of each article which deal with practical experiences in eliminating bearing troubles should be carefully noted by all engi-

neers, as similar troubles are likely to arise at any time. Concerning the matter of roller bearings as applied to electric motors, cranes and other plant machinery, we would offer the following ten important points to be looked after in order to obtain the most satisfactory results.

(1) The question of bearing selection should be given careful consideration. This applies both to the type of bearing as well as the size which should be used for a given application. The type of bearing to be used will depend upon a number of factors, such as (*a*) kind of service, whether load will be constant, variable or intermittent; (*b*) speed condition, that is, high or low speed, constant or variable; (*c*) character of load, whether it is all radial load or all thrust load, or part radial and part thrust and what are the relative proportions of each; (*d*) unusual conditions of operation, such as high temperatures, presence of unusual quantities of dust or impurities surrounding the bearings, and so forth. All of the above factors will enter into the selection of the proper type of bearing.

(2) The size of bearing will depend also to a certain degree upon the considerations mentioned above. Furthermore, the size will depend upon (*a*) the space limitations; (*b*) the diameter of the shaft under the bearings as well as the shaft extension diameter; (*c*) upon whether or not a bushing is to be used between the bearing and the shaft. When the loads to be carried are known and the space limitations are determined, it should be quite easy to select the weight of bearing to be used, that is, whether of light, medium or heavy series.

(3) Before considering the mounting and maintenance of the roller bearing, it is well to mention some important points in connection with the handling and cleaning of the bearing. Bearings are usually shipped by the manufacturer covered with some rust-resisting compound. In most cases this material will serve as a lubricant, but it is desirable to remove this covering and use a properly selected grease or oil for lubrication after the bearing is assembled. As a rule this slushing material can be removed by immersing the bearing for a time in kerosene. In many plants it is customary to keep the bearings, after they are cleaned, submerged in a covered can of kerosene until ready for use. This insures that the bearings will not become rusted before assembly. Do not under any circumstances allow bearings to lie about uncovered where they are likely to accumulate chips and dirt.

(4) In cleaning the bearings, an air blast is sometimes used. If this is done, care should be taken to see that this air does not contain excessive moisture or dirt. In many cases chips are blown into the bearings, and are very difficult to remove.

(5) Coming now to the matter of bearing mounting and the fits which should be used in this work, it must be remembered that a roller bearing is made up to exceedingly close internal tolerances and should, therefore, be mounted so that the internal clearance is maintained. In other words, excessive pressures should not be used either in forcing the inner rings on the shafts or the outer rings into their housings. In either case the internal clearance of the bearing may be so reduced, or the rings so distorted, that excessive heating will take place or in severe cases the bearing may not turn at all. The fit to be used will, of course, depend upon the size of the bearing as well as upon the particular operating conditions to be taken care of. In general, the manufacturers of roller bearings furnish information as to the tolerances of their bearings and the recommended fit allowances and it is advisable to follow closely their instructions to obtain satisfactory results.

(6) The rings of the roller bearing should be mounted so that the raceways are parallel. If it is impossible to insure that the inner and outer raceway will be parallel at all times a roller bearing of the self-aligning type should be used, as illustrated in Fig. 1. Otherwise, there is danger of the ends of the rollers being broken off due to the high pressure at their extremities. In general the bearing inner ring should be pressed firmly home against a shoulder on the shaft or against a bushing so that the ring is definitely located.

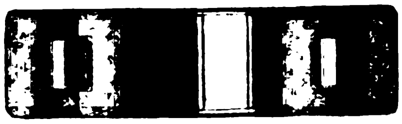


Fig. 2—This roller bearing is of the separable type.
The outer ring may be firmly fixed in the housing, as the rollers are free to move laterally across the face of the outer raceway, to compensate for expansion.

(7) Where there are excessive shock loads to be taken care of, there is a possibility of a peening action being set up between the outer ring of the roller bearing and its housing. For that reason no appreciable looseness should be permitted between outer ring and housing so that there is no chance for this peening effect to develop. A bearing of the separable type such as shown in Fig. 2 has the advantage that the outer ring may be separately and firmly mounted in the housing, irrespective of the inner ring and rollers, and in this way there is less chance for looseness to be present.

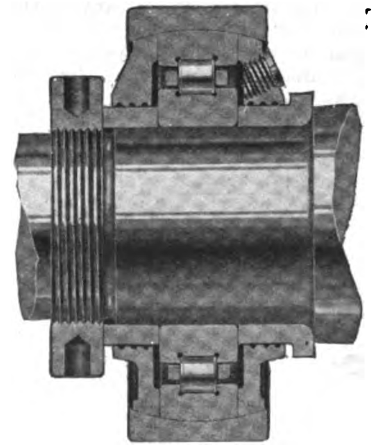


Fig. 1—Self-aligning type of roller bearing.
It is recommended that this type of bearing be used where difficulty is encountered in making or keeping the inner and outer raceways parallel.

(8) Expansion of the shaft under increased temperature should also be taken care of. If the distance between bearings is large and the change in temperature likely to be great, sufficient provision should be made for the shaft to expand without cramping the rollers on their ends. When roller bearings of the self-contained type are used one is usually fixed, while the other is free to move laterally. Roller bearings of the separable type, as in Fig. 2, take care of expansion in the bearings themselves as the rollers are free to move across the faces of the outer raceways.

(9) The kind of lubricant to be used will depend upon operating conditions. Whether grease or oil is used, it should be carefully selected so that nothing is present in it which will affect the life of the bearings. All lubricants should be entirely free from acid or alkali and should not contain foreign matter of any kind. Suitable means should be provided to see that the lubricant is kept in the bearing housing and also that dirt or grit is not allowed to enter under any conditions.

(10) The care of the roller bearing should be in competent hands. In other words, it is desirable that some person or persons be given the responsibility of looking after them. The bearings should be lubricated at regular intervals, the length of time between oilings depending again upon operating conditions. A little experimentation along this line will determine the best practice for each individual case. It is advisable to keep a log or record of each mounting and when it is lubricated, or else have a certain day of each week or month set as the day on which the bearings are to receive additional lubrication.

It may appear from the above that the proper mounting and upkeep of a roller bearing is quite difficult but such is not the case. We have only endeavored to point out the best practice based upon our experience with bearings of this type on a great variety of applications. By following a few fundamental rules of care and mounting it will be found that a well-made roller bearing will give satisfactory service over many years under the most severe operating conditions.

T. V. Buckwalter, Chief Engineer in Bearing Design and Installation, The Timken Roller Bearing Co., Canton, Ohio: The general subject, the substitution of the rolling bearing for the sliding bearing, in electric motors, is receiving constantly increasing attention. There is apparently some thought in certain quarters that much of this attention is due to the effort of bearing manufacturers to introduce their product into motors but this line of reasoning is not strictly true as those most interested in the subject are some of the large users of electric motors.

Studies made of the subject by this company, particularly among the large users of electric motors, indicate that these users attribute 70 to 80 per cent of their motor troubles to bearing failure. It must be at once granted that the actual replacement cost of bearings incidental to motor failures does not represent this percentage, but failures such as burn-outs incidental to the rotor riding on the stator, and which

are incidental to the bearing failure, should be charged to the bearings and most of the maintenance men are now taking this viewpoint. Let us look into the advantages following the application of taper-roller bearings to electric motors: We will first take up the matter of mounting and this can best be described by referring to the illustration which shows the application of taper-roller bearings to a typical induction motor, the section of the motor being taken from a layout having a rating of 100 hp. at 1,200 r.p.m. It will be observed that a pair of taper-roller bearings will take any combination of thrust or radial loads that can be imposed on the bearing in ordinary motor service, and this combination of loads might be due to a variety of causes such as misalignment on belt, shaft or gear drive, inclination of the motor from level, or use of bevel gearing on first reduction.

The bearing consists essentially of two parts: namely, the cone and roller assembly which is combined as one unit, and the cup. The distinct feature of a taper-roller mounting is that the bearings are invariably mounted in pairs and while, in the case of the electric motor, the weight of the motor is divided between the two bearings, thrust reactions, on the other hand, are taken on one or the other of the bearings, depending on the direction of the thrust.

The cones can be mounted on the armature shaft direct with a light press fit and require no clamping nuts or other accessory apparatus necessary with annular types of bearings. The cups are mounted directly in the bell housing and each cup is located endwise in one direction only, clamping rings and abutments being entirely eliminated. This provides for through reaming in machine work and maximum economy in machining operations. Housings can also be made symmetrical and much of the core work necessary with the plain bearing is eliminated entirely.

Lubrication can be accomplished by either suitable grease or a medium motor oil. Oil lubrication requires that the oil hole be located below the armature shaft to avoid leakage inward to the winding, while grease lubrication could best be provided with an ordinary grease gun, injecting the grease directly into the bearing housing but without pressure. One of the drawbacks of grease lubrication is that the bearing housing can be filled too full, leading to leakage of the grease past the armature shaft where it can be blown onto the windings. A proper charge of either oil or grease is about one-third the capacity of the housing.

The particular advantage of taper-roller bearing mounting is the economy of space on both diameter and length. The projection of the bearing housing on either end of the motor is greatly reduced, but on the other hand the symmetrical mounting provides for uniform and maximum possible ventilation.

A decided advantage of the taper-roller type of bearing is that it is adjustable for wear. Considering the long-continued service, relatively high speed, and in some cases, a high load factor, this is an important consideration. It must not be assumed that because a bearing is adjustable for wear that it will wear any faster than a non-adjustable bearing. The amount of wear in a bearing of the rolling type depends, first, on the composition and heat-treatment of the steel, the amount of rolling surface, and the reduction in unit pressure on the rolling elements and, second, cleanliness of assembly. These characteristics are all obtained in their maximum with the taper-roller bearing and are given preference. The wear is less with this type than with other forms of bearings.

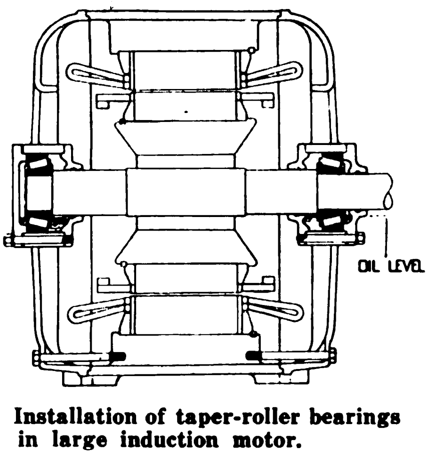
The great advantage of this form of bearing is that with a simple adjustment, by removing the shims in the motor illustrated, contact and alignment can be renewed whereas, on the non-adjustable bearing of either plain or rolling type, a complete replacement is necessary.

The second great advantage of the adjustable form of bearing is that extremely close work on the fitting of the bearings is unnecessary. It is granted that a press fit of the cone or inner race is essential on heavy motor service and on the races of the non-adjustable bearing this press fit must be very carefully handled, as otherwise an expansion of the inner race occurs. The taper bearing will function satisfactorily, regardless of whether the cone is light press fit or heavy press fit. The heavy press fit of course results in more expansion of the cone but this is automatically taken care of in making the adjustment.

The question of noise in the bearing, which is more or less present in any rolling form of bearing, can be very nicely controlled with the adjustable bearing by means of the adjustment whereas, in a non-adjustable bearing this running freedom must be nicely controlled in the manufacture and also in the mounting of the bearing.

Economy in lubrication is an important advantage following the use of the rolling type of bearing. There are instances on record of electric motors running 22 hours per day for periods of over one year without attention to lubrication.

The maintenance of the air gap without variation should improve the electrical characteristics of any form of electric motor. The variation in the air gap in the rolling type of bearing would amount to only a few thousandths, measured on the radius of the bearing and this, with proper lubrication, should be obtained only after years of service and which can be corrected by a very simple adjustment.



Installation of taper-roller bearings in large induction motor.

The relative cost of electric motors equipped with the rolling type as compared with sliding types of bearings, has not been worked out to a finality, but the indications thus far are that with the use of taper-roller bearings the difference in cost of motors will not be a material factor, the indications being that there will be no appreciable difference in cost, particularly after consideration is given to the increased cost of the bearing as measured against the decreased cost on other parts of the motor such as the armature shaft, bell housing, and simplified foundry work.

The illustration of the induction motor might be considered as typical of ordinary motor practice, and it is recognized that special forms of motors such as mill motors of the split type, railway and mining motors, must have special consideration given to the matter of bearing selection and mounting.

H. R. Reynolds, Chief Engineer, The Fafnir Bearing Co., New Britain, Conn.: In considering ball bearings for electric motors it is not our intention to criticise or condemn other types of bearings; rather we hope to bring out certain points which are factors of ball bearing service. In general ball bearings give superior service in any application. The conditions don't always require such service. However, the electric motor does.

Unfortunately, in the past the ball bearing engineer has been largely influenced by automotive design and ball bearings for industrial use have been recommended from data on hand which was not based on industrial requirements. The resultant ball bearing service was quite frequently unsatisfactory; hence early experimenters were often discouraged.

Several ball bearing manufacturers are today in a position to make very intelligent ball bearing recommendations for ball bearing machine applications, having a trained group of engineers specializing in the different fields. The electric motor has received a large share of this attention, so that today ball bearing recommendations for electric motors are made from a sound knowledge of conditions surrounding such service.

Properly selected and applied, there is no bearing made that gives as efficient, carefree service as the ball bearing. If they could be purchased and applied for the same price as other bearings there is no question regarding their universal use. Here it should be stated that quite often, once properly equipped, the manufacturer is delighted to find how closely his costs will approach each other.

Especially desirable characteristics of ball bearings for electric motor service are the following:

(1) There is no wear on the rotor shaft. (2) They are grease lubricated instead of oiled, thus assuring absence of shorts from oil-soaked windings. (3) They take care of both radial and thrust loads, thus doing away with troublesome thrust collars. (4) They insure permanent alignment, as replacement of a worn bearing promptly restores original conditions. (5) In general it is easier and much quicker to replace ball bearings than those of the sleeve type, (*Continued on page 304*)

THIS ARTICLE gives information on the different types of electrically-operated brakes, which will help the user to correctly apply them to different drives in an industrial works. Brake shoes, brake wheels and brake discs are discussed from a maintenance standpoint. This article also tells how brakes are rated, data required when ordering and details are given on the mounting, installation, adjusting, testing and maintenance of brakes together with the troubles that are commonly experienced with them.

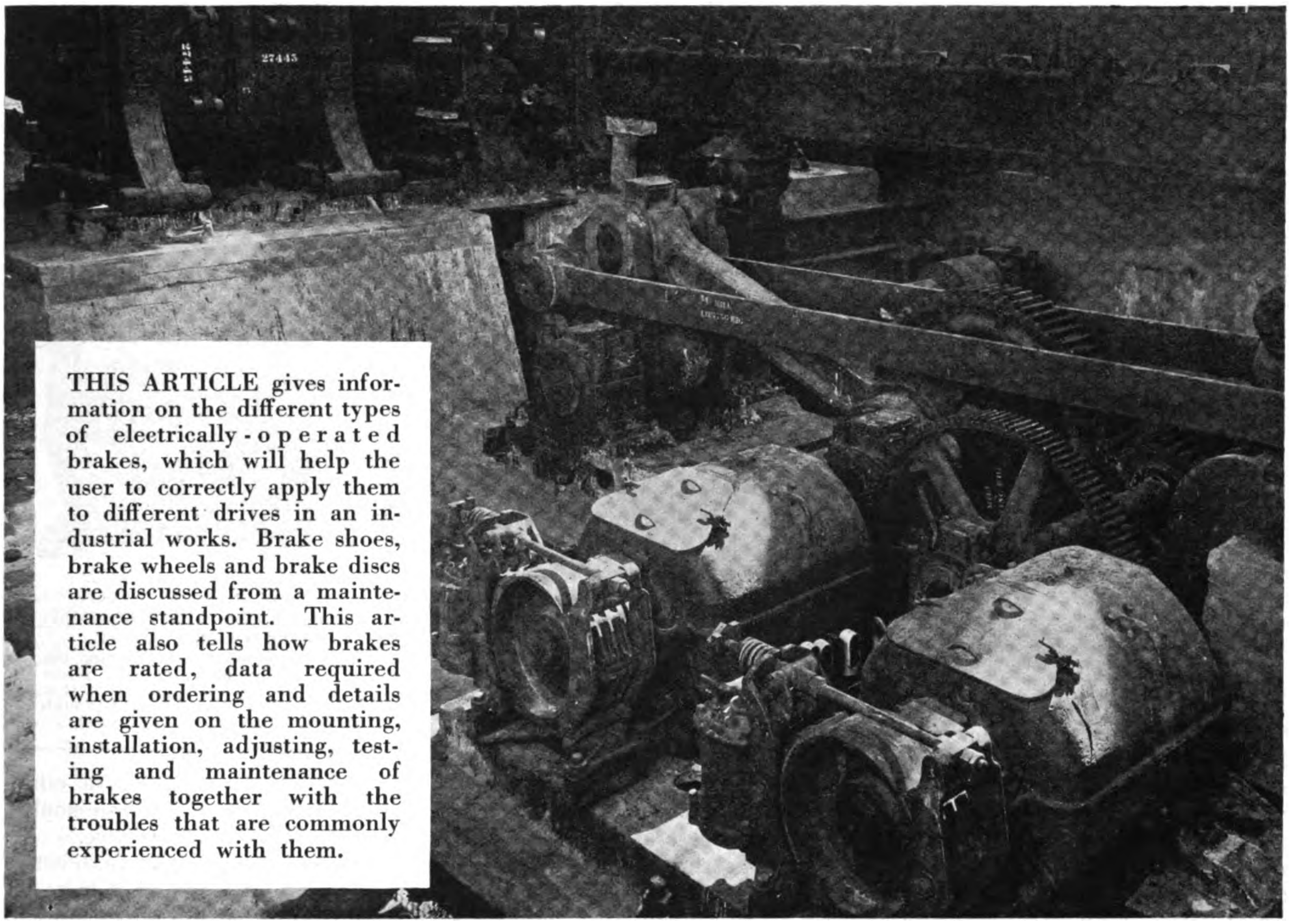


Fig. 1—These brakes are on the motors driving the tilting mechanism of a bar mill in a large steel plant.
The two motors are geared direct to the same mechanism, hence both brakes retard, stop and hold the mechanism.

Details of Service and Construction of

Brakes Used to Retard Or Hold Rotating Parts

of Cranes, Hoists, Elevators, Turntables, Lineshafting and the Like to Prevent Overtravel, to Stop at Definite Points, Hold Loads and Make Emergency Stops

By ARTHUR J. WHITCOMB
Associate Editor, Industrial Engineer

A BRAKE is a device for retarding or stopping rotary motion by friction. An electric brake is one set by mechanical means and released electrically. Some brakes are set by gravity through the action of a weight attached to a lever arm; others are set by springs. Release is accomplished by a magnet or solenoid, although a small motor is sometimes used. The function of an electric brake may be to retard and stop a motor or machine, to hold a machine at rest against some force or to perform both of the above duties.

Electric brakes may be classified according to mechanical form or as to electrical characteristics. Classified as to mechanical form, there are band brakes, disc brakes and shoe or post-type brakes. Divided according to electrical characteristics there are shunt-wound and series-wound types, alternating-current and direct-current types, and lastly solenoid-operated, magnet-operated and motor-operated types.

Brakes Classified According to Mechanical Form

The band brake is a very familiar form. It consists of a band which encircles a brake wheel. The band is lined on the inside with woven friction material, wood blocks, composition blocks, or other friction material. Usually one end of the band is anchored; the other end is pulled tight around the brake wheel by a weight or spring. A solenoid compresses the spring or lifts the weight as the case may be. Fig. 4 on page 272 shows a band-type brake and in Fig. 2 is a cross section of the solenoid that operates it.

The band brake has a large braking area, for nearly the entire face of the brake wheel is effective for

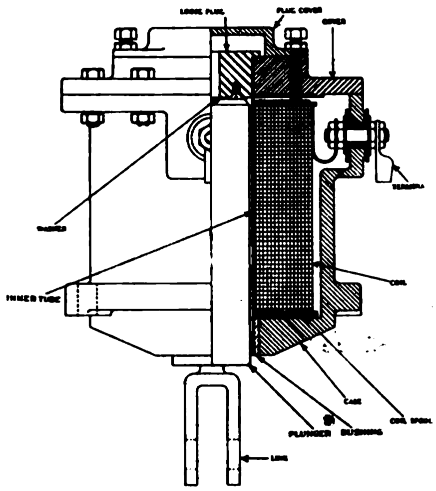


Fig. 2—A cross-section view of a solenoid used for operating band brakes.
This solenoid has a loose plug which provides a strong pull and a fixed position for the plunger when sealed. In operation the plunger engages the plug at the end of its working stroke; it continues to rise for a fraction of an inch and carries the plug with it until the stored energy is spent. Both the plunger and plug then drop back until the plug rests on its seat.

braking. The dead-end or anchored-end type of band brake exerts more retarding torque in one direction than in the other. The braking is most effective when the brake wheel is rotating in the direction which tends to wrap the band around the wheel. This limits the application of the dead-end type of band brake almost entirely to hoists, where braking is needed in only one direction.

The band brake is usually applied to the intermediate shaft of a crane hoist, where a holding brake is desired. A brake is put on this shaft to give greater safety. In case the armature-shaft brake should fail or if the motor pinion or motor shaft should break, the intermediate-shaft brake will hold the load. Quick-acting brakes on both the armature shaft and intermediate shaft will cause backlash and hammer blows to be given to the gearing. Since the band brake is slow acting, due to its long-stroke solenoid and is more effective in one direction than the other, it makes a very suitable brake for the intermediate shaft of a hoist. The quick-acting armature shaft brake will retard and stop the load while the band brake will help to or actually hold it if necessary.

The disc-type brake consists of a series of rotating plates alternating with a series of stationary plates. The rotating plates which are lined on both sides with a friction lining, are loosely keyed to a hub so that they are free to move laterally. The hub is mounted on or connected to the motor shaft. A compression spring is arranged to press the plates together and thus set the brake. The armature plate of a magnet compresses the spring and thus releases the brake. A cross section of this type of brake is shown in II of Fig. 6 and an application of it to the screw-down on the main rolls of a blooming mill is illustrated in Fig. 5 on page 273. In another form of the disc brake only one rotating disc is used which is clamped between the magnet armature and a stationary plate fastened firmly to the brake frame.

The disc-type brake is of relatively light weight, has a compact construction requiring little room perpendicular to the shaft and is quick acting. It gives equal braking torque in either direction of rotation. Due to the light weight of its moving parts it has small inertia. The disc brake is a general service brake.

The shoe brake consists of a brake wheel and a pair of shoes lined with friction material, operated through a mechanism by either a magnet or a solenoid. The shoes are made to clamp the wheel either by weights or springs acting through levers. In Fig. 3 on this page are shown brakes which are set by the action of springs. In Fig. 7 is shown a brake set by gravity acting through a weight. The shoe brake is rugged and accessible. It is arranged to permit easy removal of the armature.

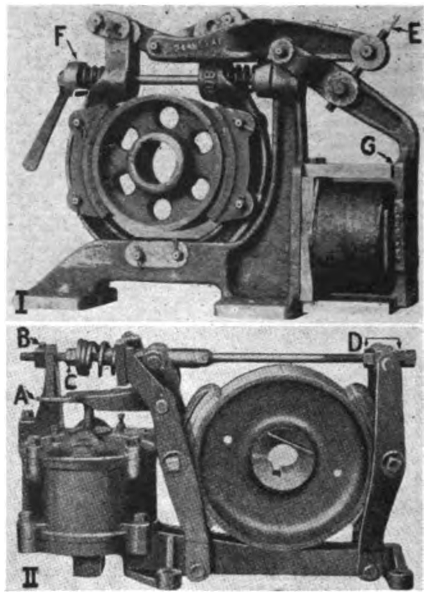
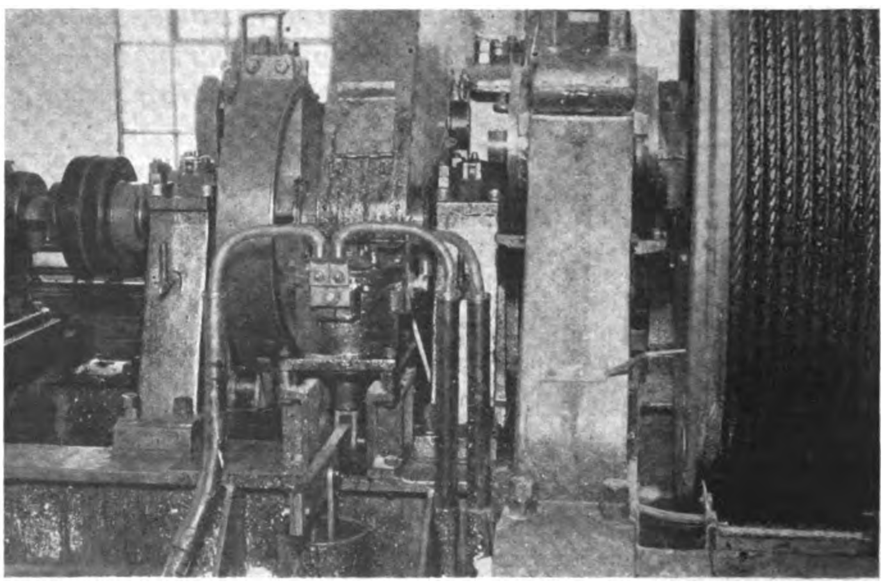


Fig. 3—I is a magnet-operated shoe brake while II is a solenoid-operated shoe brake.
Both brakes use springs for forcing the shoes against the brake wheel. These brakes are for use with direct-current motors and are series wound, although they can be supplied shunt wound.

Fig. 4—Series-wound, solenoid-operated band brake operating on a skip hoist.
The mechanism at the top of the band pulls the top of the band clear of the wheel when the solenoid releases the brake. The brake wheel is on a shaft that is coupled to the armature shaft.



The shoe brake is a general-purpose brake and is quite commonly used for heavy-duty service. A shoe brake is equally effective in both directions of rotation and it is easy to keep it adjusted so that the shoes do not drag.

Brakes Classified According to Electrical Characteristics

Classified according to electrical characteristics, brakes are designed for either direct-current or alternating-current service; solenoid-, magnet- or motor-operated; or shunt or series wound.

Direct-current brakes are made in the solenoid- and magnet-operated

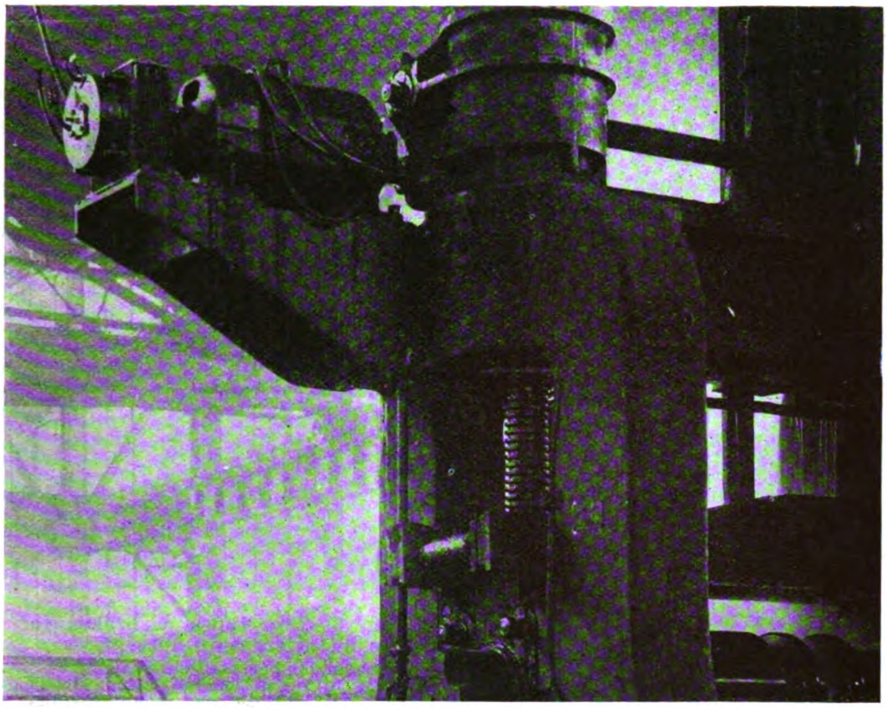


Fig. 5—A disc-type brake operated on the screw-down of a reversing blooming mill.

On an application of this kind, a brake is subjected to severe service and heavy overloads.

types. A solenoid-operated type is shown in Fig. 7 and in II of Fig. 3. In the latter a solenoid compresses a spring; this releases the brake. The braking force is controlled by the adjustment of this spring. Magnet-operated, direct-current brakes are illustrated in I and II of Fig. 6 and in Figs. 5 and 8. In these types the magnet takes the place of the solenoid and performs the same function.

Alternating-current brakes are made in solenoid- and motor-operated types. In Fig. 7. and Fig. 10 are shown solenoid-operated, alternating-current brakes. In II of Fig. 9 is illustrated a magnet-operated, alternating-current brake. This type has a laminated armature and core for the magnet. A motor-operated, alternating-current brake is shown in I of Fig. 9 and in III of Fig. 6. This brake is set by a spring and released by what is equivalent to a high-torque, squirrel-cage, induction motor driving through a pinion and toothed sector to which the brake-operating lever is attached.

Solenoid- and magnet-operated, direct-current brakes are made with the operating coils either shunt wound or series wound. Most direct-current brakes are series wound for the obvious reason that a coil thus connected is automatically de-energized and the brake set when the current is off. Also there is the absolute assurance that when the brake is released the motor has current to hold the load. The series-wound brake acts more quickly than the shunt-wound brake. In the case of a crane, an extra trolley bar and collector would be required if a shunt brake were used. Due to the fewer turns and relatively large wire of the series coil, it is more rugged than the shunt coil. However, shunt brakes have characteristics that make them almost indispensable when operated under the following conditions:

(1) Where a drift or coasting point is desired when the power is cut off from the motor on such applications as lift bridges, trolley motion of ore bridges, and the like.

(2) Where the current passes through a very low value or through zero and flows in the opposite direction at some time during the cycle as is the case in elevator and mine-hoist service. On a crane hoist, the brake is usually connected in series with the series field in lowering. If a high lowering speed is required, it is often necessary to weaken the series field to a point where the series brake will not hold open. Shunt brakes are, therefore, frequently used on the hoists of coal and ore bridges, skull crackers and similar service.

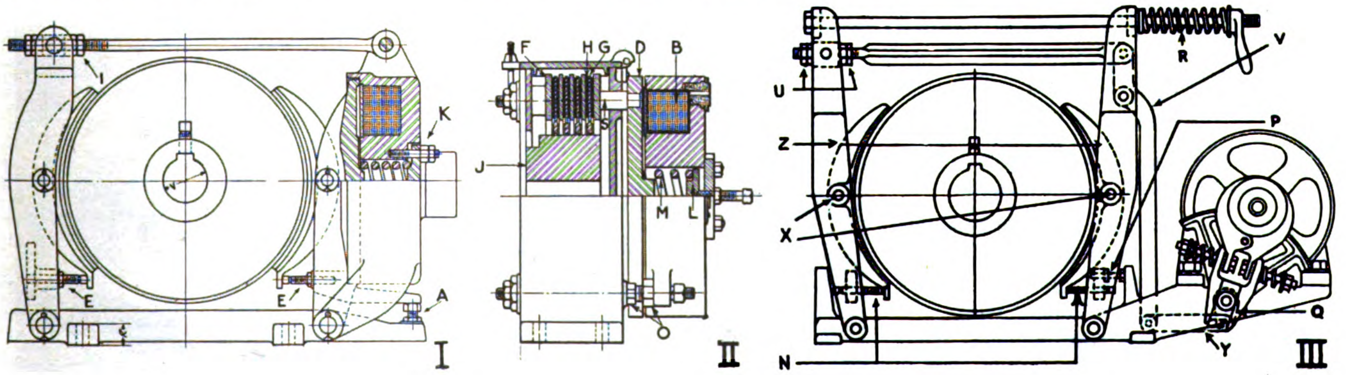
(3) In some cases shunt brakes are required where resistance is used in shunt with the armature to obtain slow-down, as on skip hoists, bell hoists and car dumpers.

The advantage of the series brake lies in its simplicity of action while the strong point of the shunt brake is its flexibility of application.

All alternating-current brakes are made for shunt operation. For three-phase service, solenoid brakes are often provided with three coils, one for each phase. The magnet-operated brake is operated single phase. The motor-operated brakes are made for operation on two- and three-phase circuits only.

Fig. 6—Structural details of three types of brakes.

In I is shown a direct-current, magnet-operated, shoe-type brake. This is the same type of brake shown in Fig. 8. II is a disc-type brake. It is released by a magnet *B* and *D* and is set by the spring *M* acting through *D* and *S* on the stationary plates *F* and the rotating plates *G*. The rotating plates *G* are loosely keyed to the hub *J* which is keyed to the shaft on which the braking is to be applied. *H* is the friction lining on the discs *G*. III is a motor-operated alternating-current brake. The motor acts through the toothed sector to the crank *Q*, through the link *Y* and lever *V*, and through the brake arms to release the shoes *Z*. The brake is set by means of the spring *R*.



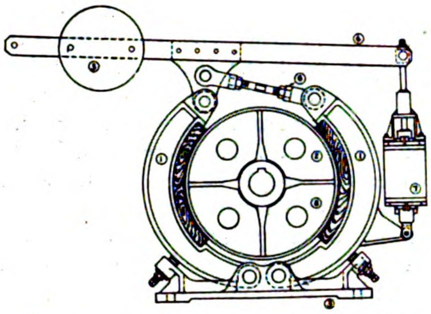


Fig. 7—Another type of solenoid-operated shoe brake.
This brake is set by a weight instead of a spring. Although this brake can be used on direct-current service it is mainly used on an alternating-current supply. For a three-phase supply, three coils are used; one coil is connected across each phase.

Special Type of Brake Giving a Graduated Retarding Torque

Some special applications require a brake which gives a graduated braking effort. A multiple-solenoid brake has been developed for this requirement. It is really two brakes in one, one solenoid being arranged to release the greater part of the total braking torque and the other solenoid to release the lesser part of the total torque. When used with induction motors, one solenoid of this brake is connected across the line and is energized only while hoisting. At standstill or when lowering, except on regenerative braking points, this solenoid is de-energized. The second solenoid of the brake is connected across one phase of the wound rotor of the induction motor. When both solenoids are de-energized, as at standstill, full braking torque is developed. When hoisting, both solenoids work together to release the brake. In lowering the second solenoid varies the braking torque according to the motor speed. The higher the lowering speed, the less motor slip, and consequently the lower the voltage applied to the second solenoid and hence the greater the braking effort. This type of brake is illustrated at *A* in Fig. 10 on page 305.

Other forms of the multiple-solenoid brake use a dashpot on one solenoid so as to secure gradual application of one solenoid while the other is applied instantaneously.

Brake Wheels are Required for Shoe and Band Brakes

Band brakes and shoe brakes require a brake wheel upon which the retarding torque is applied. Brake wheels are made of cast iron and cast steel. Cast-iron wheels wear very slowly, but are more easily broken than cast-steel wheels. Cast-steel wheels are probably in more common use. Cast-steel wheels are generally harder than ordinary steel as a balance is struck between hardness for wear and softness for machining. One manufacturer machines the brake wheels from cast steel and then subjects them to his own hardening treatment which converts the wearing surface to tool steel, glass hard. It is claimed that very long life is obtained with these wheels.

Brake wheel sizes vary. In diameter they vary from 7 in. to 30 in. according to rating. The width of the face or braking surface of the wheels varies from 2¾ in. to 8½ in. The safe permissible speeds for these wheels varies according to the diameter of the wheel. With the smallest-diameter wheels a speed of approximatly 2,500 r.p.m. is considered the maximum, while with the largest wheels a speed of about 670 r.p.m. is the highest safe speed. The inside of the face of the larger wheels is often ribbed so as to help radiate the heat generated during severe service. A ribbed wheel is shown in Fig. 8 and Fig. 10.

Brake wheels are furnished either with tapered bore or straight bore. The tapered bore is the more usual. The wheel with a tapered bore is keyed to the shaft and held in place by a nut screwed on the end of the shaft. The straight-bore wheel is pressed on the shaft and keyed.

In a shoe brake the retarding torque is developed by the pressure of the brake shoes on the brake wheel. The brake shoes are commonly made of cast iron and are fastened by pins to the lever arms through which the pressure is transmitted from the compressed spring or weight. The manner of fastening the shoes to the lever arms is shown in Fig. 3, in I and III of Fig. 6, in Fig. 7 and in Fig. 9. In some brakes the shoes are self-aligning and in others adjustments are made so as to align the shoe with the surface of the brake wheel.

The inside of the brake shoe is covered with a friction lining, usually made of woven asbestos. There are (*Continued on page 304*)

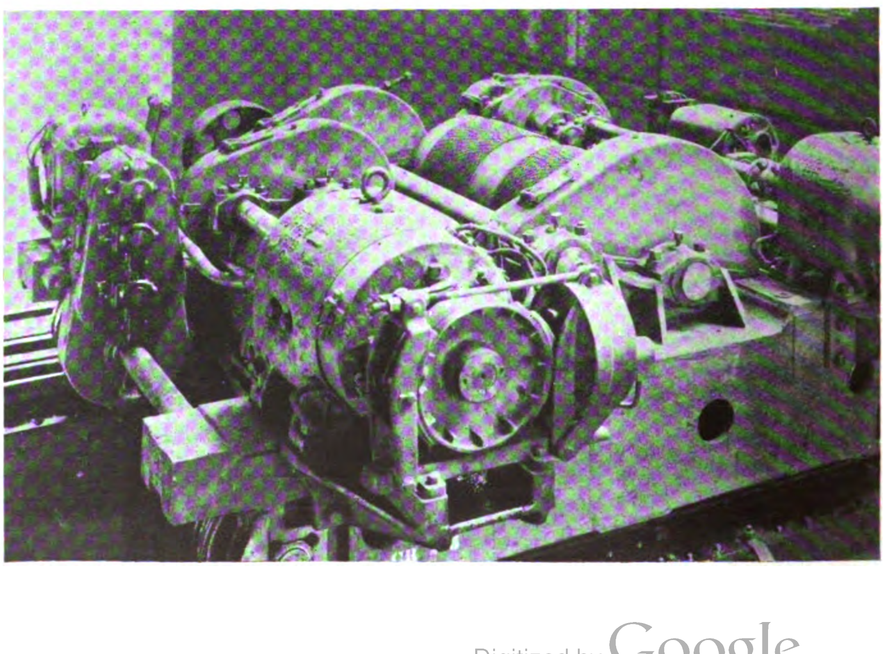


Fig. 8—A magnet-operated, shoe-type brake operating on the hoist motion of a crane.
Notice the ribbed brake wheel which aids in radiating the heat generated on the braking surface of the wheel.

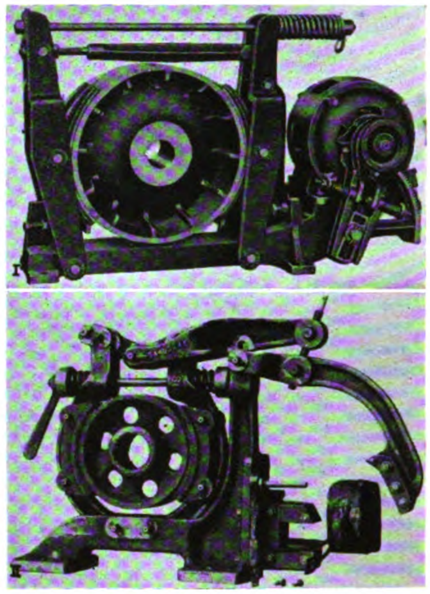
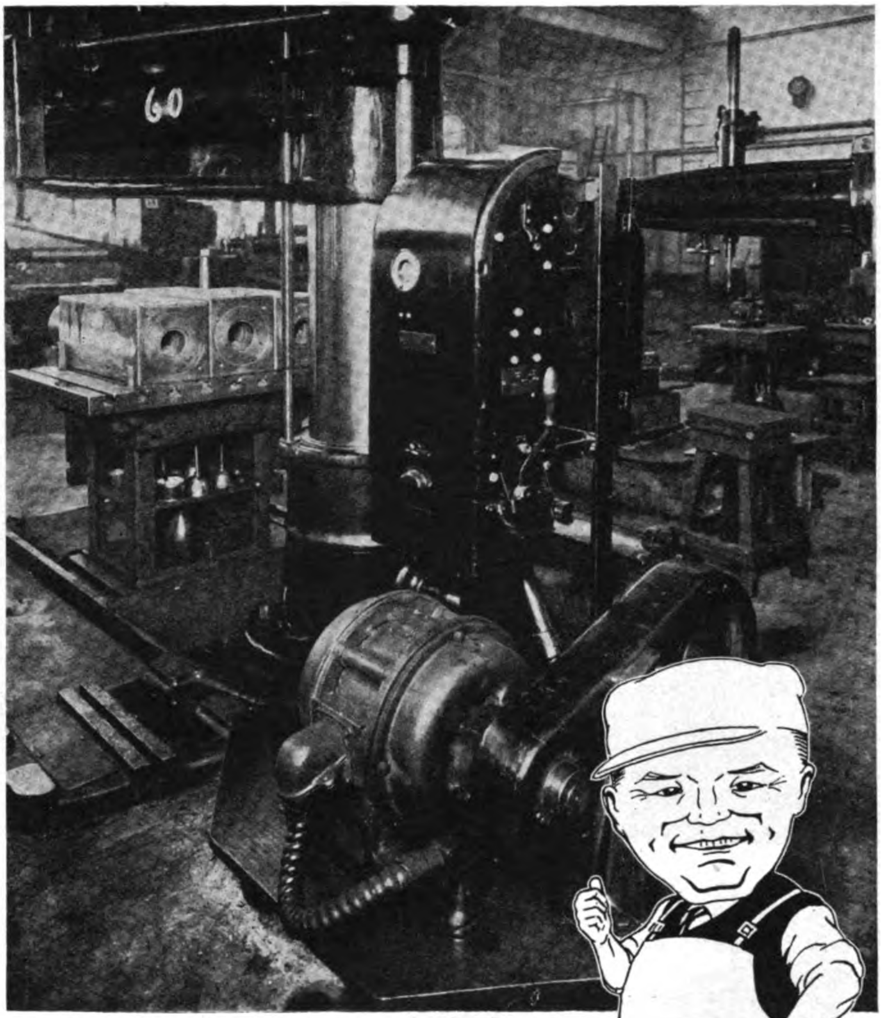


Fig. 9—Two types of brakes for use on alternating current.
I is a motor-operated shoe brake, while II is a magnet-operated shoe brake. In II, the coil has been removed so that the laminated structure of the core may be seen. Notice that the armature is also laminated.

THIS IS the second part of an article which started in the May issue. In the first part I spoke of wiring from the standpoints of safety and continuity of operation. In this article wiring is treated from the viewpoints of convenience of operation, ease of construction and cost. These two articles are illustrated with pictures of good and bad wiring jobs so that you can check up your own work and sort of make a mental examination of how good or how bad it may be. Once in a while a young fellow gets the idea that his boss is an old fogey and particular far beyond any practical necessity. But after a few years of experience, when he gets in a boss's boots he forgets that at one time he did not know it all and sometimes bears down a little hard on his men when their work is not just up to the standard that he knows it might be. Because I used to be one of those young fellows and later was a boss, I have tried in this article to point out the things that make a wiring job good and give the reasons therefor. If you are a boss pass this article around among your men. If you are not yet a boss, but expect some day to be one and want more information on any of the points discussed, just drop me a line and I'll try to give you what you want.



Some Spots and Places

Where Wiring Can Be Improved Around Machines

With Do's and Don'ts That You May Know About Arranged to Save You Time When Breaking in New Men and Helping Them to Understand Why You May Be so Fussy About Doing a Good Job

If I had to rate this job I would be forced to mark it about 99.99 per cent. The conduit with the power supply comes through the bedplate to a condulet located beneath the motor bearing and then through the conduit installed in the framework supporting the control, to a box on the rear of the compensator. The safety switch is located on the back of the framework and against the box, consequently the wiring between the switch and the compensator can be placed in this box. The leads from the compensator to the motor go through the same conduit to the condulet, beneath the motor bearing. From this point it is connected to the motor condulet by flexible metallic conduit. A minimum amount of wire and conduit were used on this job, yet the wiring is accessible and well protected.

Suggestions by

Practical Pete

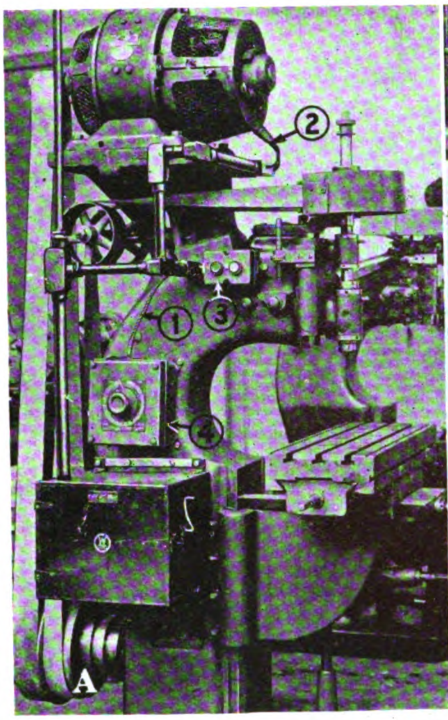
Part II

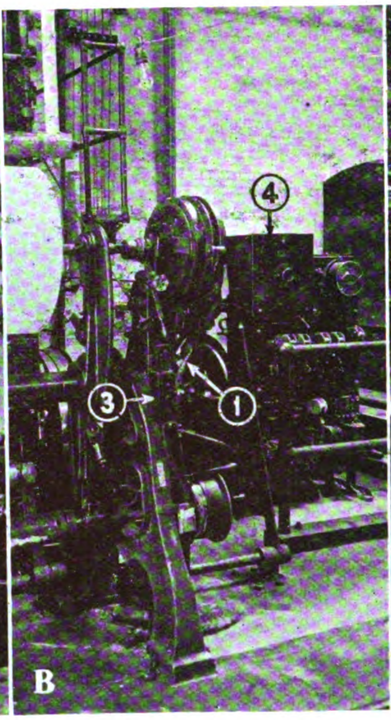
AFTER an installation has been laid out with respect to safety and continuity of operation, convenience should be considered. By this I mean the location of the various pieces of equipment so as to enable operation of the machine with the least effort on the part of the operator and also to readily enable a thorough inspection by the maintenance crew.

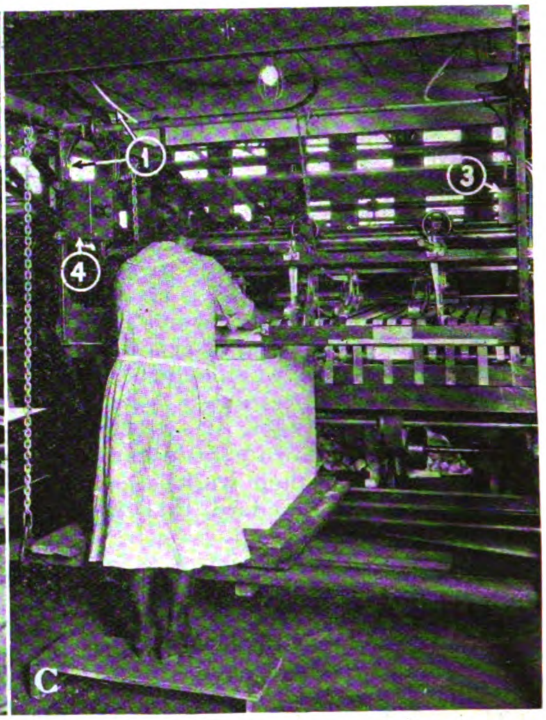
First let us consider the location of the master switch or start-stop button and the speed-regulating devices. If the machine is frequently started and stopped, the master switch or start-stop button should be placed near the operator's hand so that it will be unnecessary for him to change his position to control the machine. If the same operator controls several machines, the most frequently used master switches should be located at the nearest convenient point. For instance on a bucket-handling crane there are usually four drum controllers to be manipulated; the bucket-opening control, the bucket-closing (combi-

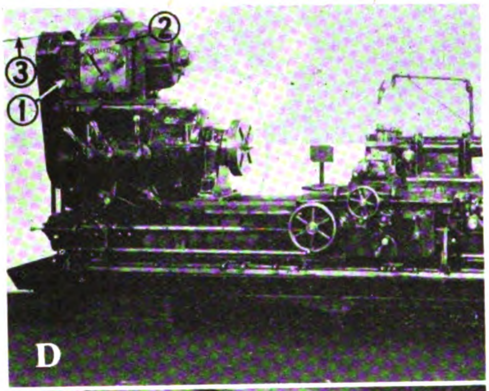
Here Are Eight Wiring Jobs

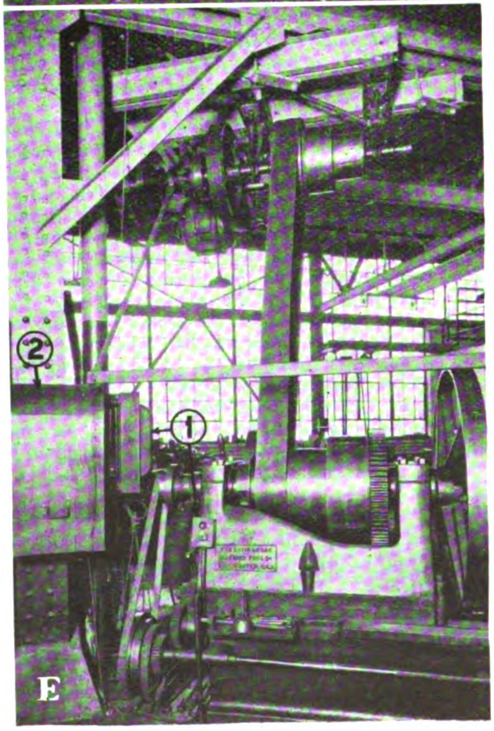
With Some Comments on the Good and Bad Features of Each











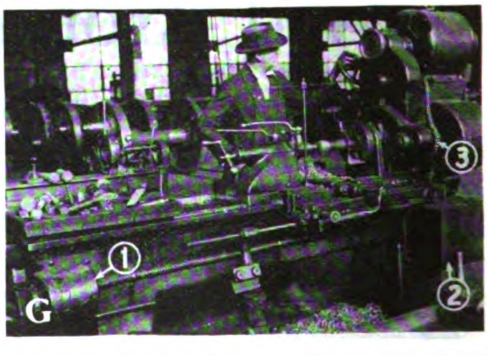
At (A) is shown an installation that is very good. There are, however, one or two points that you will say could be improved. For instance those field-rheostat leads (1) should be enclosed in the manner shown at (1) in illustrations *B* and *C*. I don't particularly like the looks of the wires leading into the motor at (2) in illustration *A*. Flexible conduit should have been run from the conduit at the push button up to the motor condulet. Notice the convenient location of the push buttons (3) and the field rheostat (4) in all three pictures.

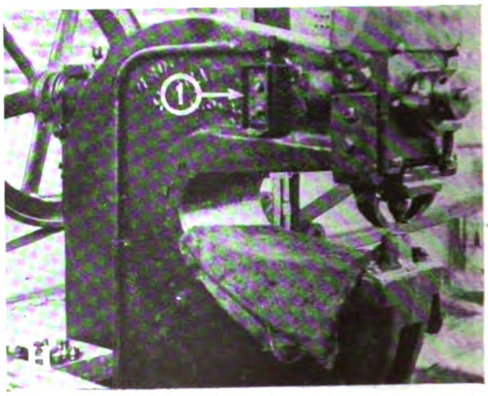
From the standpoint of convenience the arrangement of motor and control in illustration *D* is good, but when you think of safety and reliability it doesn't rate so high. Contrast the open knife switch at (1) in *D* with the push button and safety switch at (1) in *E*; also compare the starters (2) in each picture from a safety standpoint. The wiring at (3) in illustration *D* lacks every semblance of a good job.

Do you like to see conduit on the floor as shown in (F)? How much better the job would look if the conduit did not have so many odd bends. The appearance of this job might have been improved in several ways. For instance, the conduit might have been buried in the floor or, by the use of condulets, the conduit could possibly be carried on the wall adjacent to the floor.

Here is a convenient location of a controller on a lathe as shown in illustration *G* at (1). This drum in conjunction with the automatic starting panel at (2), starts, stops, and reverses the lathe. The drum controller is operated from the apron by means of a spline shaft and chain. Note the enclosure of the panel at (2) and the flexible conduit at (3).

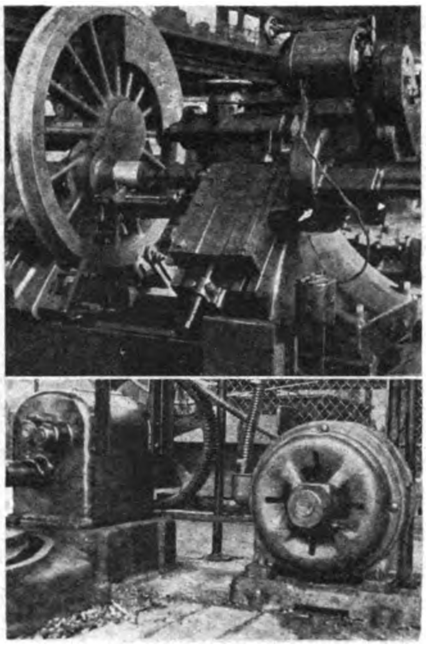
At (1) in illustration (H) is shown a very convenient lo-cation for the start-stop button of a motor-driven punch.





Here's a good job (at top), but it could be improved immensely if flexible conduit had been used instead of tape around the loose wires running from the motor to the controller.

I would have used flexible conduit because the motor is mounted on a part that is capable of being moved on the V-rails. The picture at the bottom illustrates the use of flexible conduit.



nation of these two hoists or lowers the bucket), the trolley control and the bridge control. Of these four, the bucket-opening and bucket-closing controls are used most often but the bucket-closing control receives the most use of all. On one good installation I know about, the bucket-closing control is located on the floor at a convenient height for the operator's right hand and the bucket-opening control is similarly located on the left side for the operator's left hand. The trolley control, which is used more than the bridge control, was located overhead with the handle hanging down convenient for the operator's right hand. The bridge control was similarly located at the operator's left hand. This arrangement caused the operator the minimum possible movement of his hands when changing from one control to another.

Sometimes the controllers for several machines are located in a row, the most used controller being directly in reach of the operator while the less frequently used controllers are reached by moving a little to one side.

In locating a controller it is often convenient to have the motion of the controller handle bear some relation to the movement of the machine. If the machine is a roll table or the trolley of a crane it would only be natural to move the handle forward and expect the machine to go forward. On a hoist it is customary to move the handle forward for lowering and pull it back to hoist. This is done because with the handle forward it is easier to look down to watch the hook while lowering.

I had something to say about the installation at the left in the April, 1922, issue, but it's so good that I want to take another shot at it here.

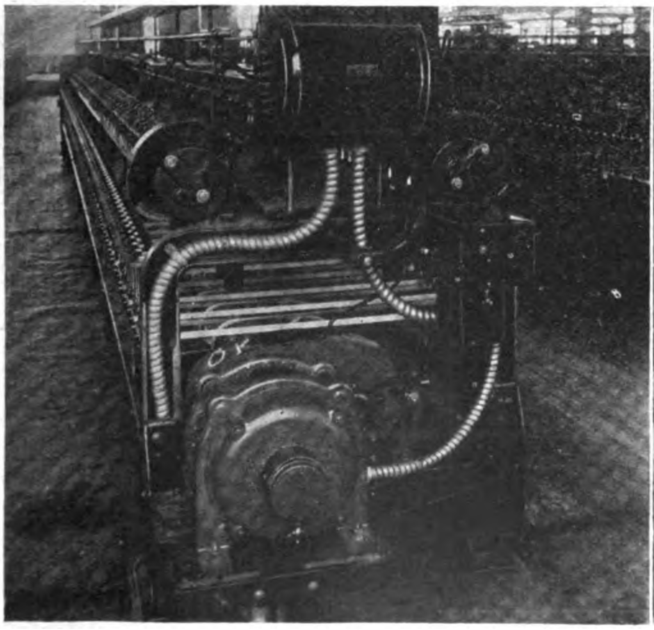
The engineers who laid this out and the contractor who put it in, make all their jobs look like this. The job at the right shows an adaptation of a similar layout in closer quarters. Note the convenience of starters, the good wiring and general safety of these installations. Here are good standards to compare your own work with.

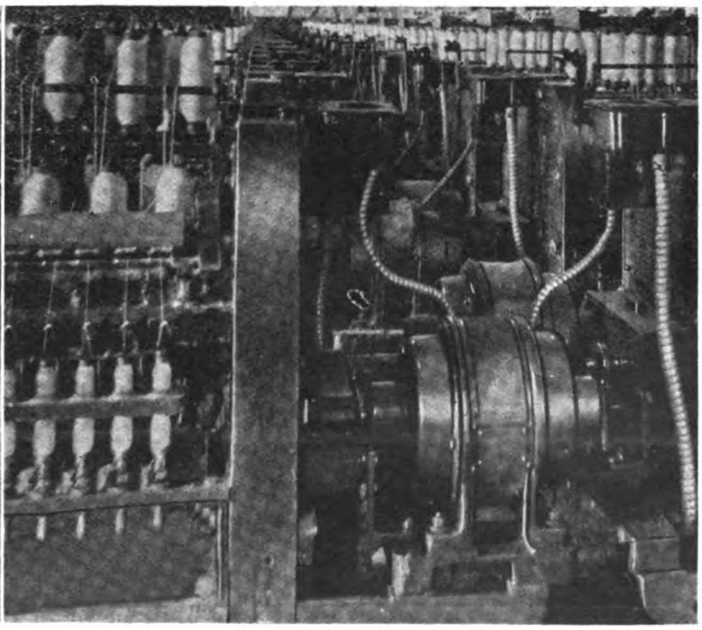
Start-stop buttons or push button stations are usually located as near to the operator as possible, depending of course upon the frequency of use. In the case of machine tools they are best located directly on the machine. Drum master switches are often used for starting, stopping and reversing machine tools. In illustration *G* on page 276 is shown a drum master switch that is operated directly from the apron of the lathe.

Auto-starters, unless remote controlled, cannot be mounted so conveniently for the operator, but when used the starting and stopping of the entire drive is not so frequent. Consequently, auto-starters or compensators are commonly mounted on a column near the drive. However, the auto-starter should not be placed on the opposite side of the machine so that in an emergency the operator has to duck around the machine or climb over a pile of machinery or material to get at the starter.

Speed regulators such as field rheostats should be located near enough to the operator so that he can stand at his work and adjust the speed to suit the job. However, safety must not be sacrificed to convenience in this matter. In any case field rheostats must not be located in exposed positions where there is a possibility of their being hit and damaged.

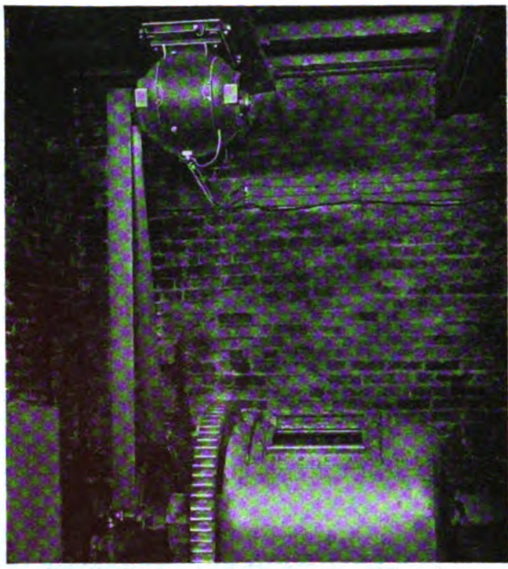
Inspection and maintenance should be considered when locating this auxiliary equipment. Drum controllers should not be located too close together or too close to surrounding structures, for when the maintenance man has to stand on his head

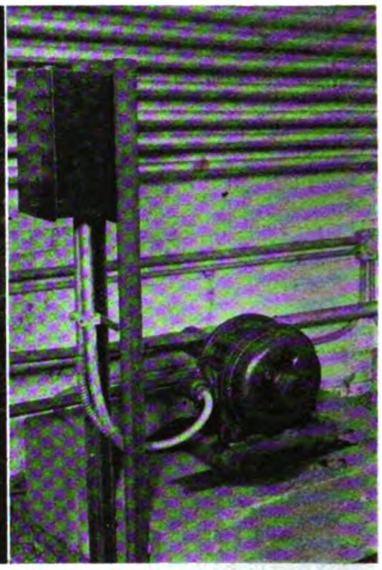




It is a shame to disgrace a motor with such poor wiring.

I know that you will agree with me when I say that I much prefer the installation at the right, for it looks like it was put in by a man who knew how. Notice the neat way the conduit is clamped to the framework, how flexible metallic conduit is run to the motor condulet, the strong mechanical connection between the flexible conduit and the rigid conduit, and the motor condulet. You can't help contrasting the wooden foundation of one installation with the concrete base of the other, the unsightly wiring with the neat appearance of the conduit and the open motor terminals with the motor condulet. The man who installed the job at the right omitted putting the padlocks on the control enclosures.





or squeeze himself into a very tight place, you can almost be sure that he will only make an inspection when he has to, and that usually occurs on a breakdown, when it is too late to take preventive measures.

Control panels should be accessible from both sides. If totally enclosed, the rear of the enclosure should have doors the same as the front.

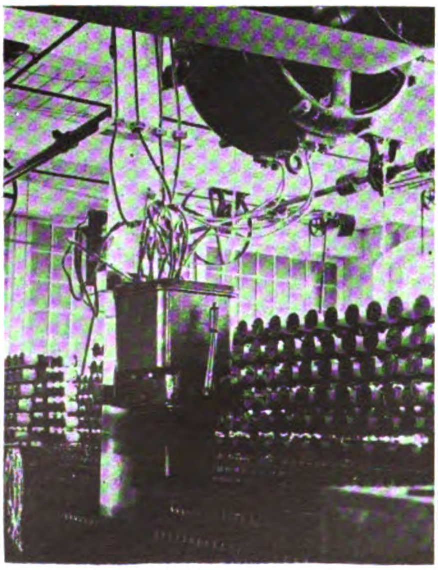
Resistors are usually located overhead and high up. In such cases provision should be made for a walkway or steps so that the resistors may be easily reached. Resistors should not be located too close together, not only from the standpoint of ventilation but also because room is needed around them to change frames or boxes, and to tighten connections. Resistor frames should not be stacked one on top of the other, for in case a quick change is required it is always inconvenient to change those on the bottom of the pile. I have always found it best to place resistor frames in a row on a rack and tier the racks. The rack should be of wood or some better insulating material. Although the end plates of the resistors are insulated from the grids, I have found that the insulated rack is well worth the trouble of installation. Due to the expansion and contraction of the frames from heating and because the grids cannot be enclosed from the dirt of the mill, the heat and dirt sooner or later break down the insulation to the end plates. When this happens with resistor frames mounted on steel racks an immediate shutdown is often required; with a similar occurrence on a wood rack no shutdown is required, in fact, the failure is usually unnoticed until the equipment is inspected.

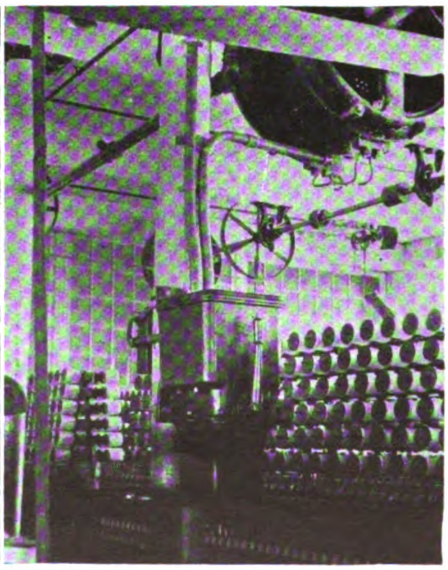
Marking the ends of wires with metal tags will be found a great help in shooting trouble and in changing equipment. The marking should be such that the two ends of the same wire may be readily identified and show where they are to be connected.

In many plants the foreman in charge of construction puts in the job according to his own ideas and quite often he is influenced by the ease of installation rather than by the ease of operation and maintenance. To counteract this, some plants require the construction foreman to confer with the electrical maintenance foreman as to how the equipment should be put in so as to provide for ease of maintenance. In one large plant I recently visited, the electrical maintenance foreman in charge of a geographical division of the plant supervises the installation of all electrical equipment. There is a construction foreman who has charge of the construction gang and he directly supervises the work, but it must be installed to suit the electrical maintenance foreman. Since the maintenance foreman has to make the equipment operate, it is no more than fair that he should have considerable authority as to how the equipment is to be installed.

Ease of Construction Should Be Considered in the Layout

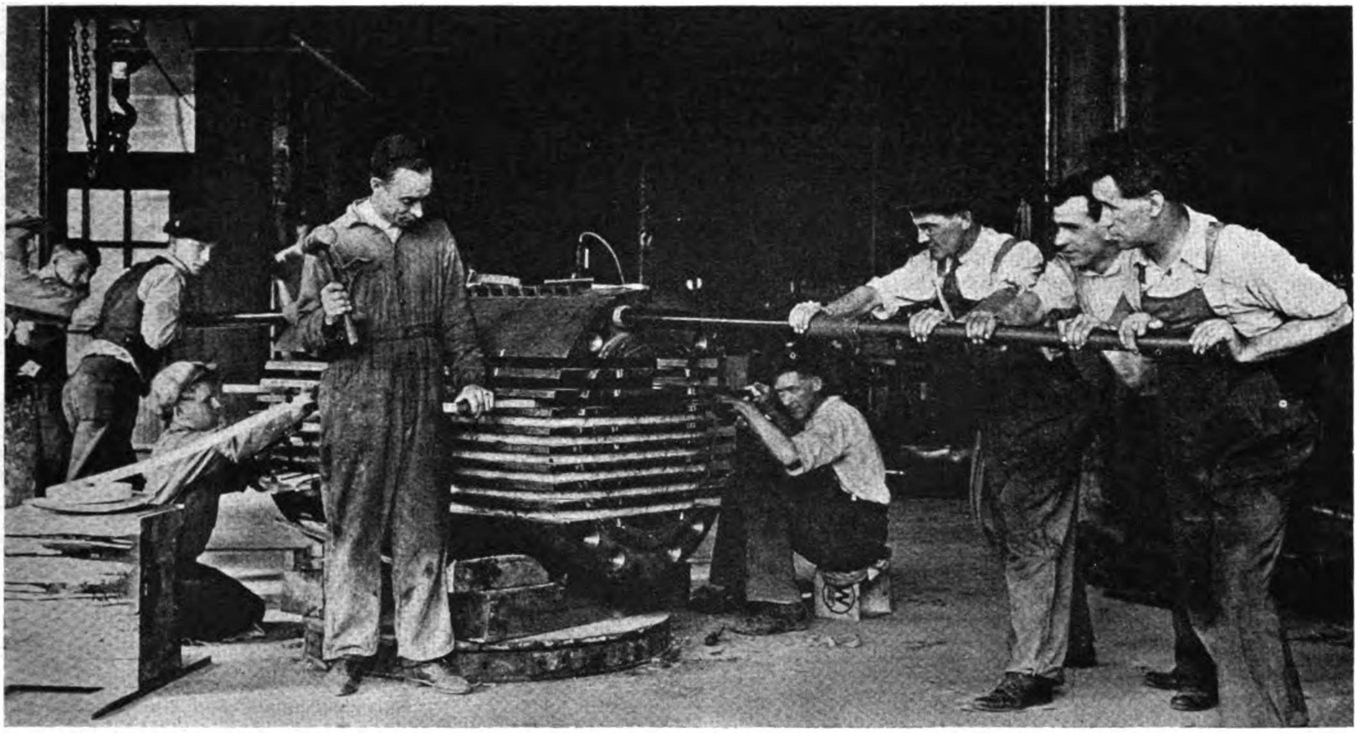
After an installation has been considered from the standpoints of safety, continuity of operation and convenience of operation, ease of construction should receive consideration. There are many ways to make a job easy to erect, but if they interfere in any way with the safety, reliability *(Continued on page 281)*





Here is what a little conduit, a few fittings and not a great deal of labor will do.

We all know that the installation on the left is sloppy, that it invites rapid depreciation of wiring and insulation and will soon lead to dangerous operating conditions. In fact, it was when the operator complained of shocks that the wiring was changed, as shown in the right-hand illustration. The cost of the change was about $18, and it would not have cost even this much if the work had been properly done in the first place.



An emergency method of rewinding a turbo-generator field.
The rotor was blocked up on the small turntable and revolved by the six men on the ends of the two sweep arms. The man sitting on the box is guiding in the copper-strap winding. Next to him is a man driving the strap straight in the slot and making it lie snugly. The man on his knees is guiding the insulating tape between the turns of copper strap of the coil. A man behind the girder on the right kept tension on the copper strap.

Here Are Details of the Job of

Rewinding the Field Of a Turbo-Generator

In Record Time Together with the Materials, the Emergency Methods and Ingenious Tools Used in Doing the Work

By A. C. ROE
Repair Superintendent, Detroit Service Dept., Westinghouse Electric & Manufacturing Company

AN IMPORTANT turbo-generator supplying power to an industrial works was partially under water during a flood. After the flood had subsided the armature or stator winding of the machine was dried out, tested and found to be in a satisfactory condition. The field winding, however, was damaged beyond hope of any temporary repair. This was due to the fact that the rotor slots were deep and that the asbestos insulation between turns soaks up water like a sponge. It would have been practically impossible to dry out such a rotor winding. It was decided, therefore, to rewind the rotor.

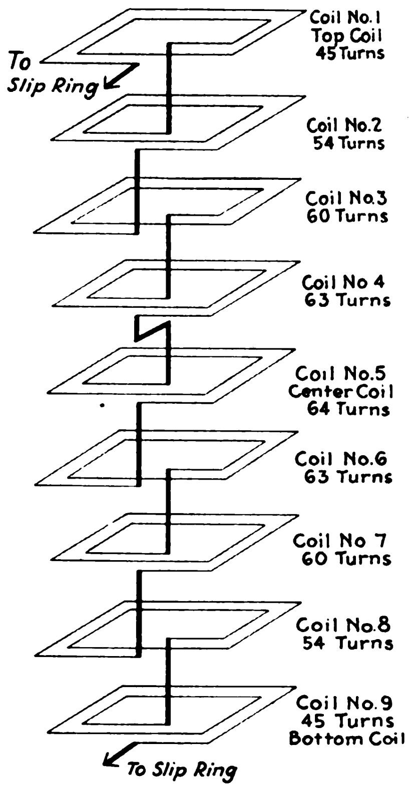
This turbo-generator was rated at 2,500 kw., three phase, 25 cycles, two poles, 1,500 r.p.m., 2,200 volts. The rotor weighed about 7½ tons and was 3 ft. in diameter. With the end discs removed, the length of the rotor was 55 in. The rotor was rather large to attempt rewinding at the power house; so it was shipped by auto truck to our service repair shop where there were better facilities for rewinding a machine of this sort.

WHAT would you do if the field winding on one of your turbo-generators should fail beyond hope of repair? Here is an account of a field failure, due to the rotor being water soaked from a flood, that meant a daily loss to the works while the turbo-generator was out of service. What was done, how it was done, the emergency methods and ingenious tools used in rewinding the rotor together with the procedure used to cut down the time required for the repair, are fully described in this article.

The job was undertaken with the understanding that the work of rewinding should continue day and night, as the inability to use the machine meant a daily loss to the concern.

As soon as it was decided to rewind the field, an order was placed with the East Pittsburgh works of the Westinghouse Electric & Manufacturing Company, the generator manufacturer, for the required winding details, such as moulded mica cells, asbestos tape, corner blocks, and connectors. These were to be brought direct from the factory by special messenger.

As soon as the field was received, the end discs and the slot wedges were removed, thus exposing the winding. A walking beam was rigged up on the hook of one of the shop travelling cranes. From one



The rotor winding has nine coils wound in nine slots.
The number of turns is marked opposite each coil. The heavy lines are the connections between coils, which are made in the cross-over slot shown in the drawing at the bottom of the page.

end of this beam was suspended an empty cable reel. The other end was arranged so that weights could be added to balance the reel as it was filled. The copper strap was unwound from one slot at a time and wound on to the reel by swinging the beam around the rotor. One man pulled the copper strap out of the slot, another wound it onto the reel, while two more men moved the beam so as to revolve the reel around the rotor.

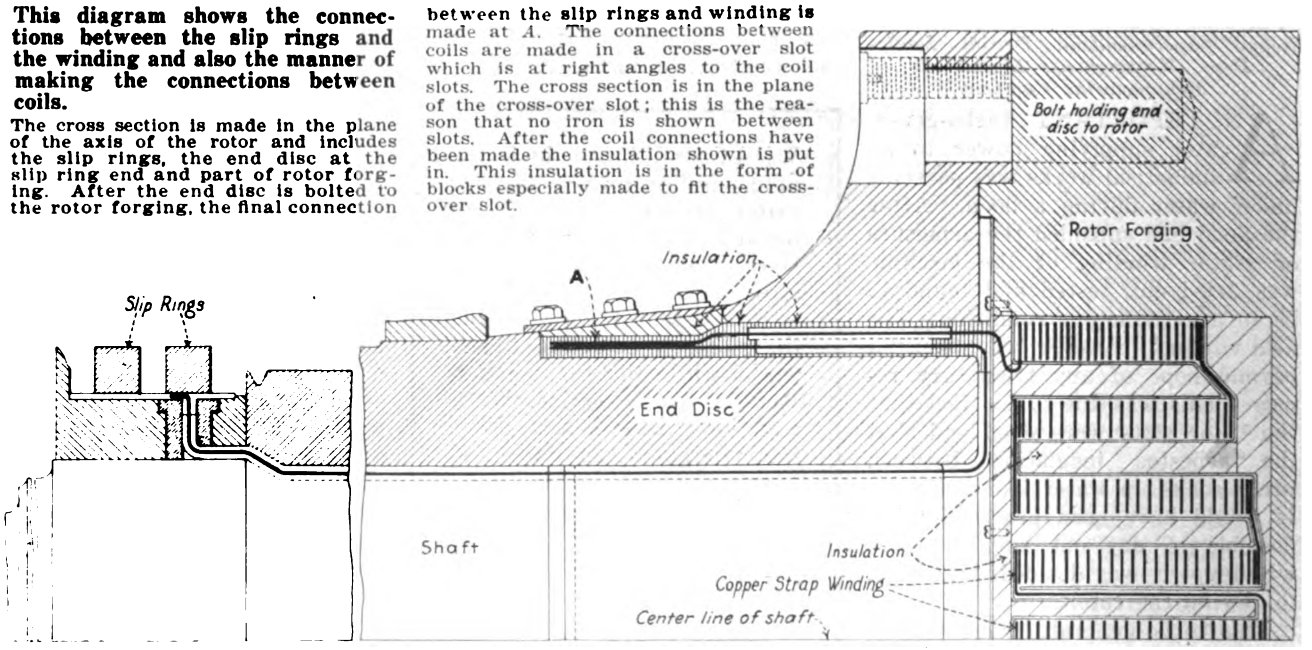
There were nine coils in the field winding, one in each slot. Each coil was wound on a separate reel and the beginning and end of the copper strap from each coil was stamped with a die so as to identify it. This was necessary, inasmuch as the coils were of five different lengths due to the difference in the slot lengths at the ends of the rotor. Sixty-five hundred feet of copper strap 1 3/16 in. by 9/32 in. was removed from the rotor.

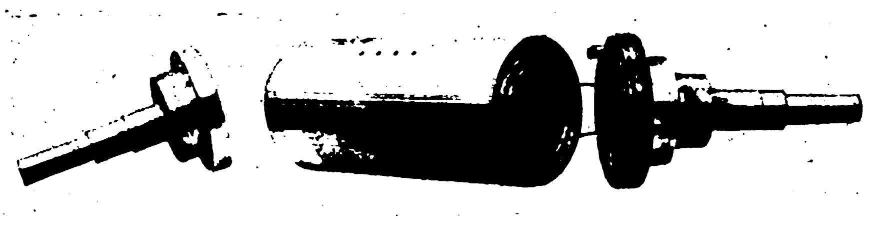
After all the coils had been removed, the old insulation was scraped out of the slots and the slots were thoroughly cleaned. Each coil was unwound from its reel and wound on to another while the kinks in the strap were straightened and the splices remade. The splices were originally made with rivets and half-and-half solder. These were cut off at each end of the splice and the ends heated to a cherry red and pounded to a tapered fit; then they were filed clean and silver-soldered. Silver solder is a combination of silver and copper and has the advantage over the half-and-half solder of having a much higher melting point and, along with it, considerably more strength.

By the time the rotor had been stripped and cleaned, the cells and other winding details had arrived from the factory. The cells were made of moulded mica 0.040 in. thick. There were four cells and eight half cells or corner pieces per slot. The cells and corner pieces were so arranged that the top layer of the cells overlapped the bottom layer of the corner pieces. After the cells and corner pieces were in place in the slot, two thicknesses of 0.020-in. mica strip were put in the bottom of the cells to prevent the first turn from cutting through the cell.

The rotor was blocked up on the rotating platform of a turntable obtained from a local contractor. There was not time enough to rig up a power-driven turntable; hence the manually-driven one shown in the illustration on page 279 was used. Six men were required to turn the machine due to its weight and the tension required on the strap copper that was wound in the slots. This tension was applied by means of two fiber blocks bolted together with four bolts; the strap passed between the two blocks, and the tension was regulated by tightening or loosening the bolts. This device was fastened to the girder at the right in the illustration at the beginning of this article. One man was required to regulate this device, while another (the one sitting on the box in the center in the same picture) guided the copper into the slot. The copper had to be tilted as it entered the slot, so another man drove the strap straight in the slot and made it lie snugly. At the left of the picture is a man feeding the asbestos insulating tape (0.007 in. thick) which was the insulation between turns of the coil. Ten men were required per

This diagram shows the connections between the slip rings and the winding and also the manner of making the connections between coils.
The cross section is made in the plane of the axis of the rotor and includes the slip rings, the end disc at the slip ring end and part of rotor forging. After the end disc is bolted to the rotor forging, the final connection between the slip rings and winding is made at *A*. The connections between coils are made in a cross-over slot which is at right angles to the coil slots. The cross section is in the plane of the cross-over slot; this is the reason that no iron is shown between slots. After the coil connections have been made the insulation shown is put in. This insulation is in the form of blocks especially made to fit the cross-over slot.





The end discs are bolted to the rotor forging above and below the parallel slots in the forging.
The rotor shown here is similar to the one on which the repairs were made. The only difference is that it has ten slots instead of nine.

shift on this part of the operation.

The coils were wound in the slots and connected as shown in the diagram on page 280. The connections between coils were made through a cross-over slot. The cross-over slot is located on the slip-ring or lead end of the rotor and is at right angles to, and cuts through, the coil slots. It is slightly deeper than the coil slots so that connections can be made from the starting ends of the coils. The connectors are of strap copper bent to pass through the cross-over slot and connect to the coil ends. The connectors are silver soldered to the coil ends.

The last two turns wound on each coil were taped with ¾-in. mica tape 0.004 in. thick, the next to the last turn having one layer half-lapped and the last turn having two layers half-lapped. This was done to insulate the last turns from the wedges.

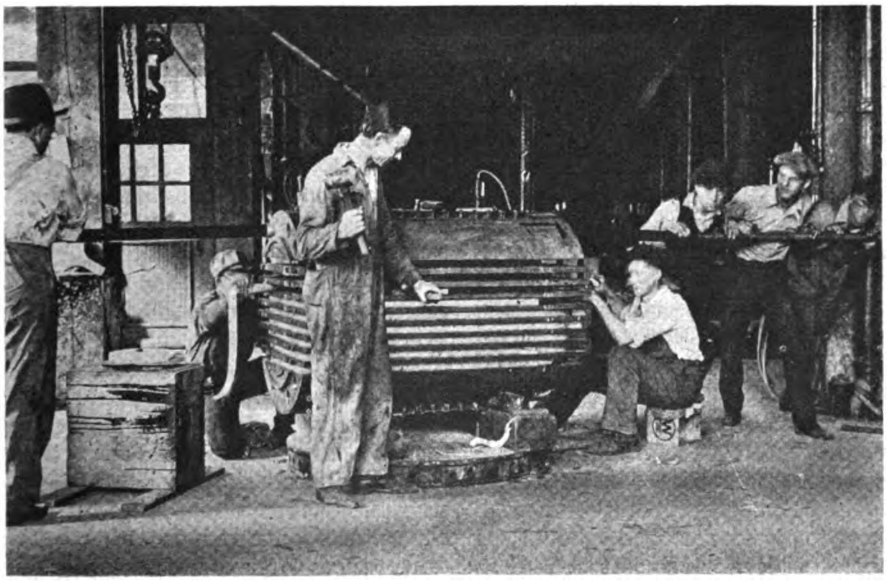
When all the coils had been wound in, the slots were filled at the corners with asbestos blocks, the cross-over slot was filled with asbestos blocks and the wedges were driven in.

As each coil was finished it was given a dielectric test between the copper and ground of 3,500 volts, from an alternating-current, 60-cycle supply. The complete winding after it was finished was given a similar test with 2,500 volts for one minute.

The rotor was now ready to have the end discs put on and the connections made to the slip rings. These connections were made as shown in the diagram on page 280. The connector from the top coil is pulled through the passage in the end disc as shown in the diagram. After the end disc has been bolted to the rotor forging, the connector from the slip ring was spliced to the winding connector as shown at *A*. The same thing was done with the connector for the other end of the winding and the connector to the other slip ring. This is done on the other side of the shaft. This diagram also shows the manner of making the connections between coils in the cross-over slot.

Rewinding this rotor required a period of ten days. It was then sent back to the power house from which it came, installed in the turbo-generator, and after being tested and balanced it was ready for service.

Ten men were required per shift on this rewinding job.
Six men, three on each sweep, turned the rotor; one man adjusted the tension on the copper strap (this man is behind the girder) two men are guiding the copper and insulating tape, while the tenth man is driving the strap so as to make it snug.



Improving Wiring Around Machinery

(Continued from page 278)

or convenience of operation of the drive they should be discarded. Conduit and wiring should be installed with the idea that the wires will become grounded within a few weeks and it will then be necessary to pull out all of the wires. If this thought is kept in mind, everything will be large enough to do a good repair job and consequently less trouble and scheming in finding out how to go about it will result.

Large junction boxes often make a job much easier to wire, especially if there are a considerable number of pipes that can be brought together at one point. I recently saw one job in which a very clever use of junction boxes had been made. It was on a hot metal crane of an open hearth. On this crane the cab is a long leg that reaches nearly half way to the ground. This leg is divided into four stories. The bottom story contains the master controllers, of which there were six (a two-trolley crane with three separate hoists) and the crane protective panel. The three upper floors contained the control panels. The supply came from the collectors at the top of the cab. Large junction boxes were located on the back of the cab, one to each floor. These junction boxes were about a foot high, and extended the full width of the back of the cab. The proper number of conduits were run vertically connecting the junction boxes; also, conduits were run horizontally from each junction box to the control panels on the corresponding floor and also from the bottom junction box to the master controllers. Conduits were run from the main collectors and from the trolley collector bars to the top junction box. Here was a simple way to wire six control panels, nine motors and six master controllers in a very accessible manner, using no excess conduit and taking up a minimum space for wiring.

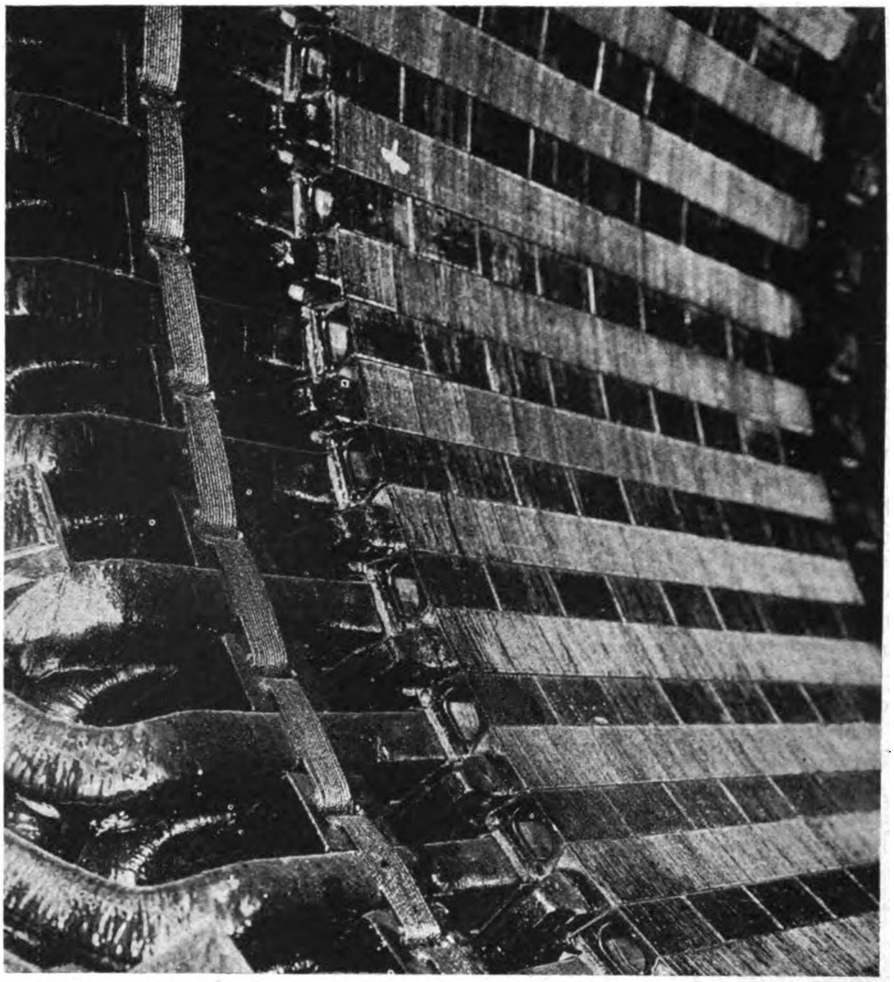
Elbows should be used wherever possible instead of a condulet with outlets at right angles because they cost less and wire can be pulled through them more quickly and easily. However, with the larger sizes of wire it is not always easy to pull the wire around very many elbows. The 1923 *(Continued on page 305)*

A GREAT DEAL of uncertainty prevails as to the methods and the value of potential to be used when making dielectric tests on equipment that has been in service for some length of time. This article discusses these subjects from the operator's viewpoint and also outlines the steps to be taken and the things to look for before the insulation is tested for defects by the application of high voltage.

How to Check Up the

Insulating Condition of Windings

In an A. C. Machine Together With Inspection Procedure and Cleaning Methods Before Making Dielectric Tests



Dirt should be removed from all accessible parts of the winding. Loose dirt can be brushed off by wiping or by compressed air. Oil-soaked dirt may be removed with gasoline, benzine, or carbon tetrachloride. Important places to clean are the points where the coil is adjacent to the slot and around the clamping supports, as well as where the end turns cross each other.

ONE OF THE fundamentals of successful operation of electrical generating equipment is frequent, thorough, and systematic inspection. Such inspection will often give warning of approaching trouble and thus allow the operator to take precautions that will prevent a serious breakdown and consequent damage to the generating equipment.

It is the practice in some plants to inspect each generator every day. This is an excellent precaution and highly recommended. It is understood that operating conditions may not permit such frequent inspection but nothing should interfere with the thorough inspection of each machine as soon as it is shut down. No definite rule can be laid down, but the principle should be recognized that frequent inspections are vital to the proper maintenance of all generating equipment. All inspections should be thorough. While a casual inspection is perhaps better than none, the value of an inspection depends on the care used in making it.

The inspection should always include the armature windings and field coils of the main generator, insofar as they are visible and accessible, the armature, field coils, and commutator of the exciter (if there is one), the collector rings, all brushes and brush-holders, bolts, nuts, dowels and all other mechanical and electrical parts and fittings. Lubricating oils are injurious to insulation and also to concrete foundations, and all bearings and oiling systems should be examined for oil throwing and leaks. In the case of steam turbines, the turbine itself so far as possible, and the valves, valve gear, governor, throttle, governor-control motor, bearings and all other accessible parts should be included.

Haphazard inspection by anyone in the plant cannot be considered systematic. A definite routine of inspection should be standardized and every part should be taken up in order. Superintendents should compile a list of all parts subject to inspection and insist that inspectors use this list, checking off each item as it is examined. The inspector should be thoroughly familiar with what to look for and should be drilled in his work so as to guard as much as possible against the omission of any part.

Ways of Cleaning and Preserving Insulation of Windings

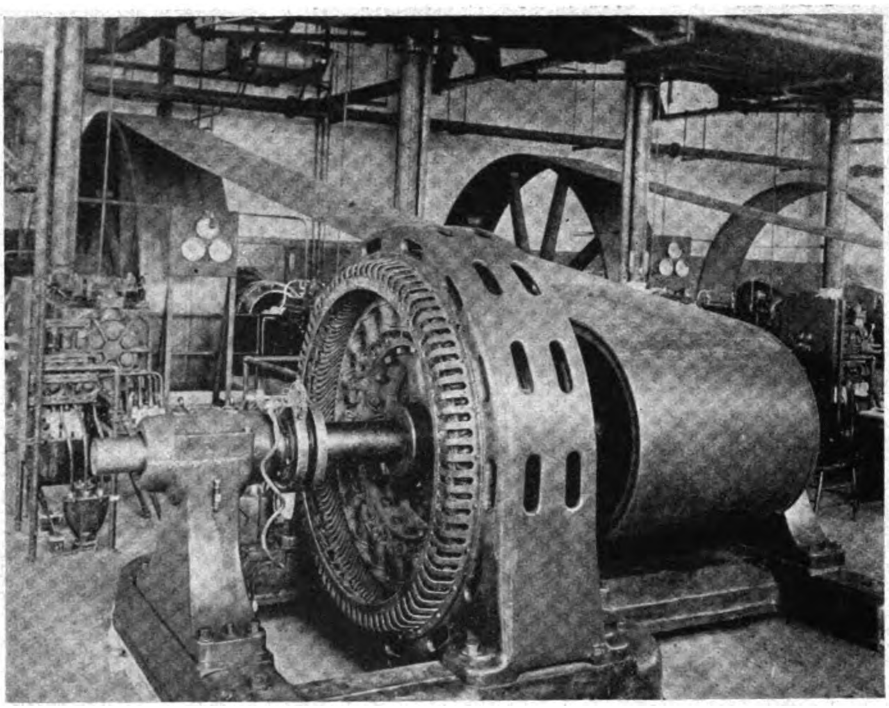
All generating equipment will accumulate dust and dirt in the course of time; even the use of air washers does not altogether eliminate this trouble. This dust and dirt lodges in the air ducts and on the ends of the windings, interfering with the free circulation of the cooling air and the radiation of heat from the windings, and at the same time increases the fire hazard.

The life of generating equipment may be prolonged by frequently blowing out the dirt with compressed air. In large turbo-generators this is a difficult matter, if indeed it is possible, owing to the design of the generator frame and end bells. On other types of machines, however,

such as engine-type generators, the air ducts and windings are more exposed and are accessible for this form of cleaning. If possible, the compressed air should be used every day but, before doing so, care should be taken to make sure that the air stream is free from water.

All generating equipment should be thoroughly cleaned once a year or more, if operating conditions are such as to require it. Special attention must be given to machines operating in localities where the air is contaminated with dust, lint, coal, dirt, cement dust, and the like. Under such conditions, arrangements should be made for a thorough cleaning at frequent intervals. To insure that this periodic cleaning be thorough, the end bell covers and similar parts should be taken off to expose fully the end turns of the windings and the air ducts. The revolving field should also be removed, so that it can be cleaned and examined, and at the same time permit the cleaning and inspection of the inside of the armature.

Loose dirt can be removed by wiping, brushing, the use of compressed air, bellows, or by some form of vacuum cleaner. Should dirt and dust be lodged with oil, it may be reremoved with gasoline, benzine or carbon tetrachloride. In using any of these, limit the quantity to that required for the purpose in hand. Too much liquid is liable to flush the dirt into inaccessible places. After using any of these solvents, all the surfaces to which they have been applied should be carefully and thoroughly dried. Care should be exercised when using gasoline or benzine because of their inflammable properties. Special attention should be given to ventilation, not only because of the danger of explosion but also because the fumes of all three are injurious to the workman, particularly if working in a pit where fumes are likely to collect. In using gasoline care should be taken to obtain a good quality, since a poor quality is liable to leave a coating of oil or other substance on the windings and in inaccessible places, which will cause the rapid accumulation of dirt and dust. Test all gasoline that is to be used for cleaning purposes, by allowing a small quantity to evaporate in a porcelain dish. If the quality is good, no residue or odor will remain. After cleaning and before re-assembling the parts, spray the exposed windings with a high grade of air-drying, insulating varnish. While the machine is disassembled, all electrical parts and connections and all mechanical parts should be carefully examined and such tests applied as may be considered advisable.



Engine-type machines such as this are easy to clean.

By sliding the stator to the left the stator winding is exposed for cleaning and all portions of the rotor are made accessible for maintenance work.

General Procedure for Making Dielectric Tests

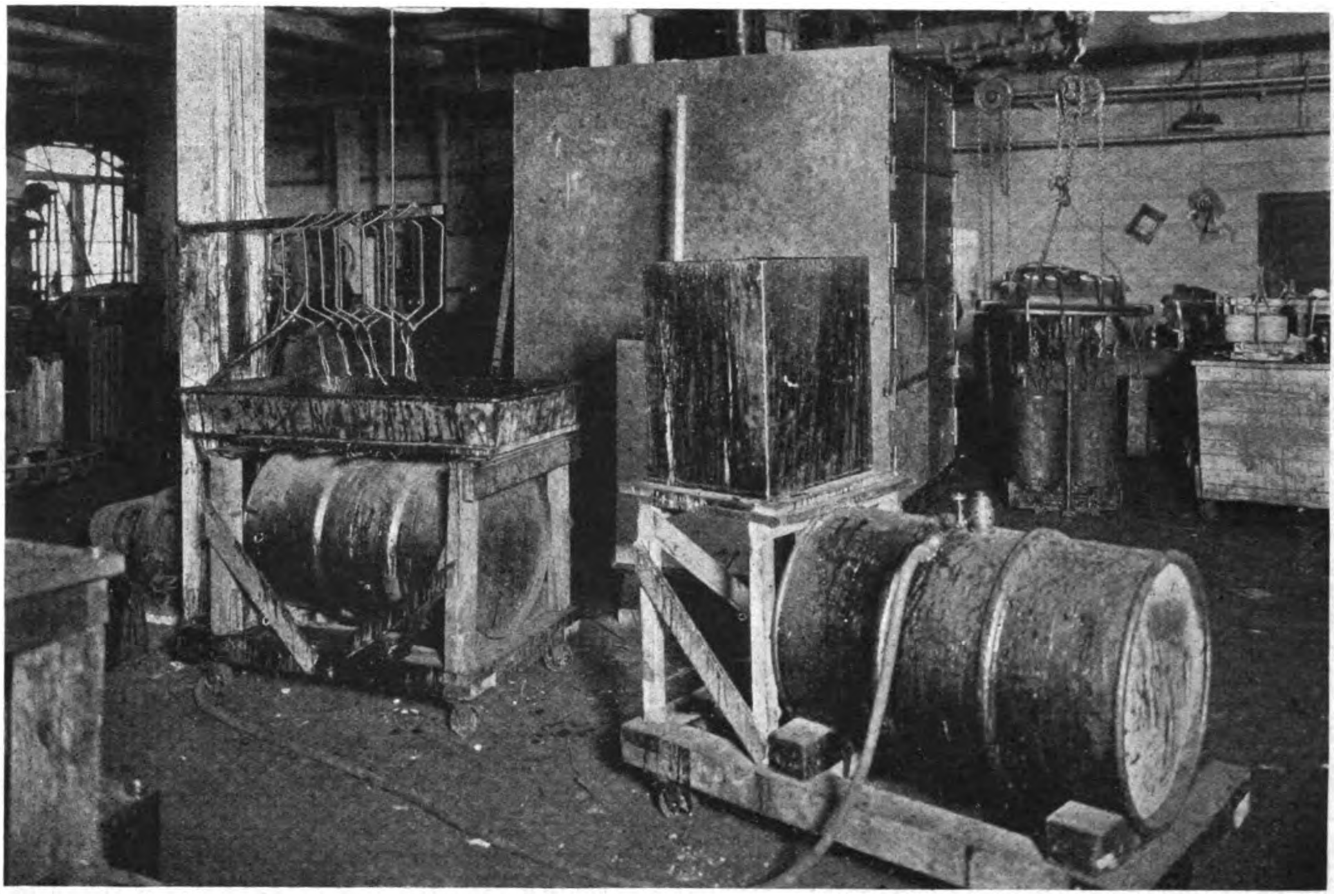
No definite rules can be established for testing generating equipment that has been in operation for any length of time. The permissible test depends particularly on the age of the machine, on the character of the service to which it has been subjected, and on the type of insulation used on the windings. All insulation deteriorates with age and use, particularly where organic material forms a large part of the total insulating material. An old machine or one that has been subjected to severe operating conditions will not stand, nor should it be subjected to, the same test that might be applied with safety to a comparatively new machine.

There comes a time in the life of all equipment when the deterioration reaches the point of breakdown and, when this occurs, expensive repairs are usually the result. For the purpose of enabling operators to determine the approach of this condition, various tests have been devised and are now in use.

The "megger" and other similar devices are frequently used to measure the resistance of the insulation. There are many factors which call for experience and good judgment in interpreting the results obtained with these instruments; however, they are very widely used.

The combination of high voltage (at least as high as that of the machine under test) and direct current gives very satisfactory results. A new way of obtaining this combination is by the use of the kenotron measuring set. With this set the condition of the insulation is determined by measurement of the leakage current through the insulation to ground.

There frequently arises the question of applying a high-potential test, or what might be called a generated over-voltage test (running the generator at over-voltage by increasing the excitation or speed, or both) to determine the condition of the insulation. The answer must take into account the various insulating materials used, the age of the machine, and the operating conditions, particularly regarding overloading and periodic examination and cleaning. General approval in the abstract, at least, will be accorded the statement that "the insulation of all generating equipment should be maintained in such condition as to withstand safely the application of a 50 per cent over-voltage test." (*Continued on page 306*)



This photograph was taken in the repair shop of Huntington & Guerry, Greenville, S. C., and shows dipping and varnish tanks and drying ovens used in connection with motor and transformer repairs. After dipping and baking operations, a coat of air-drying varnish applied by brush or spray provides an insurance against breaks in the continuity of the baked film.

Here are Some Practical Suggestions on

Best Ways to Use Insulating Varnish

When Protecting Windings Against Moisture, Oil, Metallic Dust and Insulation Troubles Arising From Various Other Causes

By H. L. HAZELTINE
Engineer of Insulation, The Sterling Varnish Co., Pittsburgh, Pa.

BEFORE attempting to decide on the insulation for a given piece of apparatus, the nature of the service to which it is to be subjected must first be carefully studied and the proper kind of varnish chosen that will give the best results.

Next the structure of the apparatus should be examined closely, particularly as to the insulation other than varnish that has been used, so that the method of applying the varnish may be so varied as to provide the exact degree of protection desired. The general type of the liquid insulation will not be changed by the type of the coil, but it may be necessary to change the consistency at which the material is to be applied.

When insufficient attention has been paid to these details trouble is quite often experienced and it has been the custom in the past to lay these difficulties at the door of the particular varnish used. The rule then seems to be to change the varnish without further investigation. Occasionally the problem may appear to be solved—not because the new varnish is a cure-all but because the method of treatment happens to be right for the particular kind of work involved and the particular kind of varnish used. But when attention is directed to a new job, the trouble often returns and the same process of changing varnishes has to be gone over again. The source of the difficulty often actually lies in some minor change that has been made in the manufacture or design of the apparatus. The trouble can then be remedied by modification in the method of treatment. For example, a change from an untreated cotton tape to a varnished cambric tape demands a change, not in the varnish, but in the application.

Considerable throwing of varnish has been noticed in the case of high-speed armatures where a change has been made from a partially-closed slot to a straight slot. This was not due to a change having been made in the varnish formula, as was first supposed, but to the fact that the

throwing was never observed with the former design, although it did occur.

It is not always necessary to change the type of varnish when trouble develops unless, of course, the results previously obtained were not all that was to be desired and unless these results cannot be improved upon. Sometimes a modification of the treatment solves the problem.

It will be impossible in this article to discuss the proper way of handling all kinds of work. It will be necessary, therefore, to confine ourselves to a discussion of the general principles involved in securing specific results and leave the variations to be worked out by the individual.

In describing the different methods of varnish treatment to secure protection against the various external conditions such as water, acids, oil and metallic dust, it must be remembered that we are dealing with simple cases, such as where water resistance is the sole consideration. Hence in our selection of the proper material we are not allowing ourselves to be influenced by such considerations as the mechanical or binding strength demanded, or other complications, such as water resistance plus oil resistance. The methods of treatment will be the same. The only variation necessary will be in the nature of the varnish used. It is believed that the user, once he understands the simple principles involved, will be able to so combine the recommendations made with his previous knowledge of varnish as to enable him to adjust his methods to the most complicated cases.

TO SECURE the proper electrical insulation for a particular job is a problem in which guesswork cannot be successfully used, especially when it comes to the matter of varnish application. When the fundamental principles involved are once thoroughly understood, however, the details of the actual work are not at all difficult. Insulation against electrical stress calls for a procedure that will provide for external or atmospheric conditions and mechanical strains. In this article Mr. Hazeltine takes up the practical details of methods that can be used under different operating and service conditions.

Making Coils Waterproof

Case 1—Treatment of Coil without Impervious Insulation for Low-Voltage Service.—The simplest case is that of the coil wound with cotton-covered copper wire and then taped with cotton or linen one-half lapped, having no impervious insulation to retard the passage of the varnish into the coil.

To obtain perfect moisture resistance the varnish chosen should be one that has been carefully designed so that the dried film will not only shed water but will not absorb any through its surface.

The service which will test the protection obtained to the utmost is when the finished coil is to be operated on low voltage intermittently and subjected to atmospheric moisture. This is much more severe than high-voltage service, even when coils are actually submerged in water, because there is little heat generated in the coil itself and hence the moisture that may penetrate will not be driven off again in the form of vapor, as would be the case in the latter service.

General Requirements.—To insure perfect moisture resistance, it is absolutely essential that the coils be completely sealed. That is, the coating of varnish must be perfectly smooth and glossy and there must be no breaks in the continuity, such as cracks in the varnish film. Furthermore, all untreated tape is covered with many fine hairs which tend to pierce the varnish coat. When they do their action is like that of a wick and moisture is drawn from the air by capillary attraction into the interior of the windings. These fibrous hairs must be completely covered and many coats of varnish will be required. Time and production expense can be saved by singeing the coils before varnish treatment. This can be done by drawing them rapidly through an open gas flame, taking particular care that the movement is sufficiently rapid so that while the hairs are burned off the tape does not actually catch fire. This will remove most of the hairs but, of course, some may be left which must be covered.

Method of Application.—First heat the coils in an oven at 212 deg. F. for a sufficient length of time to drive out all moisture and occluded air from the windings. This preheating is important, since the varnish cannot completely fill the coil and so conduct the heat from the interior as long as stagnant air or moisture remains. Remove the coil from the oven and immerse it while still hot in a tank of varnish and allow it to remain until all bubbling has ceased, and longer if possible. The air in the coils being rarified draws the varnish into the interstices. When bubbling stops it is an indication that the varnish has replaced the air fairly well, but the action will continue for about 15 or 20 min. longer.

Withdraw slowly and drain for a sufficient period to allow the varnish to partially set. Too much emphasis cannot be laid upon proper draining as otherwise the varnish may collect in pockets and make the thorough drying very difficult. Next place the coil in a well-ventilated oven and bake at any temperature desired that will not injure the fibrous insulation. It is advisable during this bake to reverse the position of the coils so that the top during draining is at the bottom during baking. This insures a much more uniform coating, since the first effect of the heat upon the varnish is to soften it and cause it to flow. By this reversing the heavy accumulation on one side is largely avoided.

Upon removal from the oven, sandpaper lightly so as to smooth down any unevenness caused by the fibres that may have been left after singeing.

The first application is the filling coat. Since the varnish contains considerable solvent which on evaporating leaves some space unfilled, other applications must be made in exactly the same manner in order to secure the perfect seal already described. Even with the careful singeing and sandpapering, several applications will be necessary—three or four at least. This may be followed by a coat of air-drying varnish applied by brushing, dipping or spraying. The function of this latter material is simply an insurance against any breaks in the continuity of the baked film.

Unfortunately this elaborate process of treatment is costly. It is, therefore, recommended only where the moisture condition is severe and extreme measures must be taken for protection.

In order to cut down production costs many shops omit the singeing and sandpapering operations alto-

gether, although they serve to reduce the number of coats required. In such shops as many applications of baking varnish as are practicable are applied and are followed by one or more very heavy applications of an air-drying or finishing varnish. In this method, since much dependence is placed upon the air-drying product, care must be used in its selection. Results obtained by this practice are surprisingly good.

Remarks.—It matters little how the final protection is secured so long as it is borne in mind that perfect moisture resistance can only be obtained when a perfectly smooth, glossy coat of enduring varnish has been applied having no breaks in the continuity. Do not use an alcohol-solvent, finishing varnish to protect against extreme moisture conditions.

Case 2—Treatment of Coil without Impervious Insulation for High-Voltage Service.—As mentioned before, if this same simple coil is to be subjected to high-voltage service where considerable heat will be developed, such great care need not be taken to obtain the perfect seal, since the moisture which finds its way into the interior will be evaporated during the period of operation. Any type of baking varnish could be used with the expectation of obtaining good results, even though the coil were actually immersed in water during the operation. More care must be taken, however, to be sure that the coil is well filled. Dead air is a non-conductor of heat. If it is allowed to remain inside the windings it will, therefore, prevent the free passage of heat from the interior of the coil to the exterior.

If an insulation test is to be made upon the finished coil it will be best to use the same amount of care in securing a perfectly covered and sealed outer surface as in the first case. Otherwise the moisture in the windings will give a low value to the resistance when taken cold, although during the operating period this will rise rapidly due to the heat generated. The same general method of application should be followed as has already been outlined in Case 1, with those variations necessary to fit the shop requirements of the individual.

Case 3—Treatment of Coils Having Impervious Layer Insulation for Low-Voltage Service.—We will next take a layer-wound coil having treated or untreated paper between each layer. It is almost impossible to thoroughly dry a varnish on the inside of such a coil by the application of heat from the outside, since the only places for the solvent to escape and for air to enter for the oxidation of the drying oils are through the ends.

Method.—When such coils are to be operated on low voltage thorough impregnation with varnish is unnecessary, since little or no heat will be generated which must be transmitted from the interior of the windings to the exterior.

It is best, therefore, first to preheat as before and then quickly dip while still hot into a bath of a very heavy, viscous varnish. Remove at once allowing the coil to remain only a few seconds at most. Drain and bake as before. The varnish being very heavy and the coil being in the bath for a very short time, little more than an outside coat will be obtained. The varnish should not penetrate much more than one-quarter or one-half inch. As many additional applications must be made as will be required to obtain the perfect seal before described.

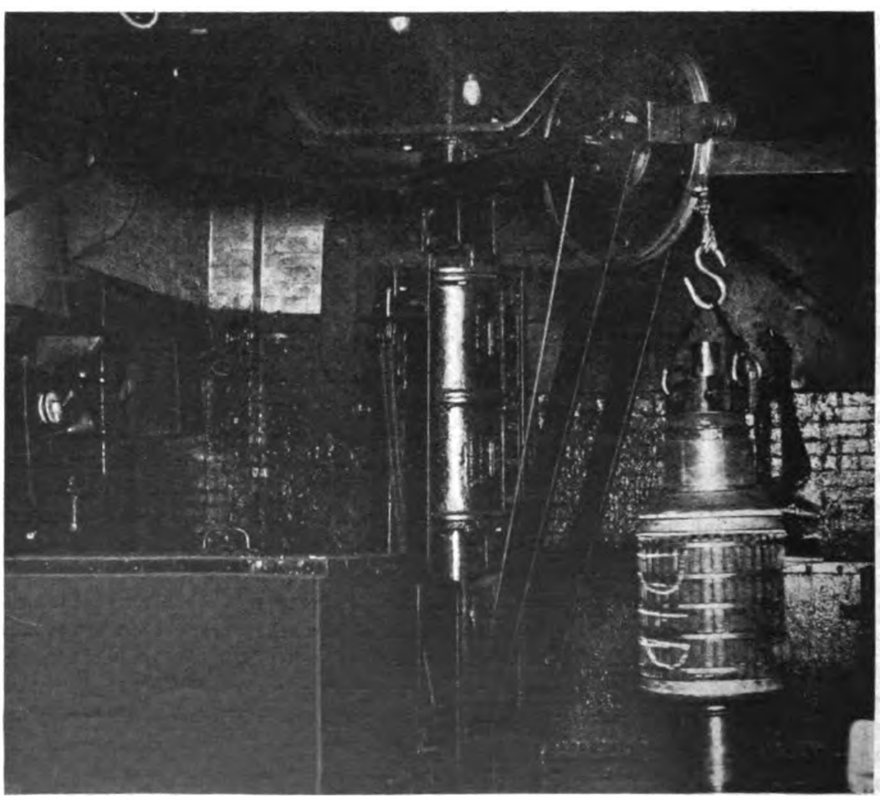
Case 4—Treatment of Coils Having Impervious Layer Insulation Designed for High-Voltage Service.—When, however, coils of this type are to be operated on high voltage where considerable heat will be developed, thorough impregnation must be obtained.

Compound Method.—A solid compound could be used, forced in by means of the vacuum-pressure impregnation system, providing its melting point is sufficiently high so that it will not be liquified and run out when the coil is in operation. Finishing coats of an air-drying varnish should be applied afterwards so as to insure perfect water resistance. A baking product would not be suitable in this case because of the danger of liquifying the compound during the baking and forcing it out through the partially dried varnish film.

Varnish Method.—If a varnish is preferred it may be applied by brushing a thin coat on each layer as it is wound. A fairly rapid drying product should be used and the paper layer insulation drawn tightly so as to squeeze out as much solvent and excess varnish as possible. After the coil is wound it should be thoroughly baked, then taped and given additional surface treatments in the same manner as above.

Case 5—Treatment of Coils Wrapped with an Impervious Tape.—Coils which are to be wrapped with varnished cambric or Empire cloth after winding, such as motor

Armatures should be dipped vertically with the commutator end up. The varnish should be thinned to such a consistency as to give maximum penetration and clean draining. The commutator end should be up, otherwise varnish may lodge under the commutator bars and be carbonized by the heat in service, causing short circuits.



field coils, should receive one or more applications of varnish as described under Case 2 before the outside taping is done. Stay tape or clips may be used to hold the conductors together during this operation. After the varnish has been properly baked the clips may be removed and the varnished cambric put on, and over it the cotton tape. Then apply as many coats of varnish as may be required to provide a seal that will be perfectly impervious to moisture. These later applications serve not only to cover the cotton tape but to seal the edges of the treated tape underneath.

Treatment of Field-Coil Assemblies.—It is always good practice in the case of d.c. field coils, especially where the motor is subjected to heavy duty, to immerse and bake the whole frame in varnish after the coils have been bolted in place. This serves to cover any abrasions that may appear in the treated surface due to handling during assembly. If connections are made after the coil has been bolted down the process serves to cover the joints with a smooth glossy surface which prevents water from getting in and creeping down into the coil underneath the insulation.

Case 6—Treatment of Armatures or Stators.—It is the practice in many shops to wind armatures or stators of small size with white or untreated coils and then dip the complete armature in a baking varnish. If this is done some slight degree of moisture resistance is usually sacrificed in order to provide mechanical or binding strength as the purpose of dipping complete armatures is to hold the coils in place and prevent their vibration, to fill all cracks between coils so as to prevent the deposition of dirt or moisture, to seal the laminations and prevent their vibration, to cover the iron and prevent rust and to protect against oil which may be splashed on the windings.

Method.—The armature should be preheated and dipped vertically, commutator end up, in a varnish thinned to such a consistency as to give maximum penetration and clean draining. The commutator end should be up because otherwise varnish may lodge underneath the commutator bars and later be carbonized by the heat in service, thus causing short circuiting. Great care should be taken to provide thorough draining so as to guard against pockets of partially-dried varnish which may be thrown out by centrifugal force when the machine is in operation. It may be necessary in some cases to tilt the armature during the draining period to prevent this.

Special attention should be paid to the oven.

Baking varnishes dry by oxidation and therefore require a considerable quantity of fresh air during the drying period. See that this air supply is properly assured and then see that the proper temperature is being obtained.

If the varnish is allowed to set partially before baking, the shafts and other iron parts may be cleaned by washing with benzine. The armature should be baked in a vertical position so as not to throw it out of balance by too great an accumulation of varnish on one side. If it is absolutely necessary to bake horizontally the armature should be rotated a quarter turn every 15 minutes during the first hour or two of baking. Several treatments should be given so as to obtain a smooth, glossy surface which will easily shed water.

Protection for the Weak Points.—It must be remembered, however, that this treatment alone will not produce an absolutely water- and moisture-proof job. An insulation resistance test may show up badly after the armatures have been in storage for some time. This test is usually made from coil to ground and hence one must look between the conductors and the core for the source of difficulty. The weakest points are where the coil enters and leaves with the iron. Special attention must therefore be paid to the slot insulation.

If Empire cloth or varnished cambric is used it may be put in the slots or it may be simply added to the coil insulation. If the latter is done it will be better to treat the coil first before assembly and before the tape is put on. In any case the impervious insulation should extend at least ⅛ in. beyond the ends of the slots so that the coil insulation will not be cut by the sharp edges of the outer laminations. It is the custom in the larger motors to treat the coils first in the manner just suggested. After the treated tape and the white outer tape have been put on they may be singed or sandpapered and then additional varnish treatments given to provide a smooth, glossy finish. The varnish for such work should be a somewhat elastic product; that is, one that when dry will not crack or peel when the coil is pulled or bent when it is assembled. After the coils are in place the complete armature should be given one or more dipped coats for the reasons mentioned in the first paragraph of this case. The varnish, however, for this latter operation should be of the hard, baking type since one of its chief requirements is mechanical strength to hold the coils in the slots and protect them against injury due to vibration.

Remarks.—One of the disadvantages in this practice of dipping and baking the complete armature is that when repairs are needed it is practically impossible to lift a coil and a complete rewind is usually necessary. On the other hand the coils do not have to be replaced so often, since burnouts caused by the wearing away of the insulation by vibration are largely eliminated. Another advantage is that insulation which is bruised in assembling the coils is completely covered and sealed. The advantages gained by the practice are so great that they completely overbalance the disadvantages.

Armatures that come in for repairs, particularly those subjected to heavy duty, should be thoroughly cleaned, given a single dip in varnish and baked in order to renew the life of the insulation. This is, of course, in case a complete rewind is unnecessary. Not only is the insulation renewed in this manner but laminations (*Continued on page 306*)

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT F. E GOODING A. J. WHITCOMB

Chicago, June, 1924

How Much Do You Know About Your Work?

A SUBSCRIBER recently wrote: "I have just received my first copy of INDUSTRIAL ENGINEER and read it from cover to cover. I am very much interested in it, particularly the Question and Answer Department. In order to prove this I am taking the liberty of sending answers to two of the questions asked by readers."

INDUSTRIAL ENGINEER is written for the men who carry the practical responsibility of keeping the electrical and associated mechanical systems of industrial works in proper operating condition. It constitutes a permanent record of their work and the methods used in performing this work.

The Question and Answer Department is conducted as a means of rendering the fullest possible service to the readers of INDUSTRIAL ENGINEER. It is the medium through which any reader can obtain the information he desires on any problem that comes up in his daily work. His question will be answered by other readers who have solved the same problem in a practical and satisfactory manner. Conversely, this department affords every reader an opportunity of helping his fellow workers in the solution of problems that are of mutual interest.

If one desires neither to ask nor answer questions he can still spend a very profitable hour or so in reading the new questions and determining for himself how many of them his experience or education would enable him to answer. These questions cover a wide range of practical problems in the installation and operation of electrical and mechanical equipment. They are a bird's-eye view of the maintenance problems encountered daily in the industrial works of this country. To answer a question may require the knowledge gained by years of practical experience; or it may depend on the proper application of some half-forgotten fact or principle.

In any event the list of questions published each month in INDUSTRIAL ENGINEER affords an excellent means of testing the quality and extent of your information and ability to handle the maintenance problems of an industrial works.

Read carefully the questions in this issue. For your own sake outline in your mind the answers to as many questions as possible. If you think your answers will be helpful to the readers who asked the questions—send the answers to us.

Possible Savings By Motor Rearrangements

IN ALMOST any plant where load tests on motors are not regularly made some surprising leaks can be discovered with a set of indicating and recording meters. In one particular plant where such a test was made on ten induction motors totaling 355 hp., it was found that six of them were underloaded to such an extent as to operate at an objectionably low power factor and that the friction load was 142 hp. By simply rearranging the motors so that the ratings were more suited to the maximum loads, one 25-hp. motor and one 50-hp. motor were discarded and the loads distributed among the remaining eight. By adjusting the belting and shafting the friction load was reduced from 142 hp. to 108 hp., the efficiency of the motors increased an average of about 2 per cent and the power factor of the motors increased from 3 to 12 per cent.

The cost of this rearrangement was $282, but the actual saving in energy required the first year after the change was $1,441, through a reduction of 30 kw. in the load which amounted to a saving in the power bill of 69,920 kilowatt hours.

This installation furnishes a practical example of the cost of negligence or indifference to simple maintenance problems such as adjusting belt tension, avoiding complication in shafting and drives through rearrangements of machinery, attention to lubrication, knowing the actual loads carried by motors and checking same with nameplate ratings, checking the actual time certain motors are standing idle, and other operating conditions that change with changes in arrangements of machines or the work done on them. An investment in a set of portable indicating and recording testing instruments and load checks on all motors at least four times a year will usually pay a nice profit. Besides, the data thus made available will eliminate a lot of guesswork when new power drives are to be installed.

What Makes A Good Wiring Job?

ONLY too often is wiring about machinery considered a matter of bending pipe and pulling wire. In the article on page 275 of this issue and the one that appeared in the May issue some other side lights, such as safety, continuity and convenience of operation, and ease of construction, have been thrown on this subject. Before the wiring job is considered complete and the machine ready for operation, a careful inspection should be made of all parts of the installation, followed by tests made on the apparatus controlling the machine.

This calls to mind the case of a 1,000-kw. rotary converter operating in a large industrial works. This machine was given a superficial examination and then started up and thrown on the line. For several months the machine operated satisfactorily; then during a

period of heavy production it failed due to a grounded field. Changing the field on this particular machine was a half-day's work for a gang of six men. Production in the plant was interrupted and an unnecessary loss entailed.

A very careful examination and test disclosed the fact that the field discharge resistance was incorrectly connected to the field switch. The field switch is opened and reversed on this machine only when it is necessary to "slip a pole" to make the direct-current polarity come right. It so happened that the polarity on this machine usually came right of its own accord without the necessity of slipping a pole. Consequently the field switch was rarely used. However, it was used often enough to cause the field insulation to break down.

Wiring about machinery is only half done when all the equipment is installed. Before the job is considered as complete, a careful inspection should be made of all parts, followed by tests of all connections and apparatus. Only after this inspection and tests should the machine be put in operation.

By-products of Paint-up—Clean-up Campaigns

INDUSTRIAL plant men after an application of good paint, brush and broom have noticed some interesting results which had not been entirely anticipated, unless these men had had similar experiences before and knew what would happen. Many of these campaigns are no doubt the application in industry of the good housewife's spring housecleaning. One of the best excuses for getting the average industrial man to apply white paint to the interior of factory buildings is, that he can get a greater application of light usually with a decrease in the lighting bill. A decreased accident hazard is another result which goes hand-in-hand with better lighting and brighter surroundings.

There is another point, however, which is not so generally considered—the effect upon the morale of the workers. For example, in one gas generating plant the operators were required to make written reports of conditions every five minutes. The reports had become so undecipherable that they could not be read and, in addition, the men made numerous mistakes through inability to decipher their own writing correctly and make proper subtractions and additions. The superintendent finally gave each man a broom and required him to keep the space at his own machine brushed up. An almost simultaneous improvement in the appearance and legibility of the reports was noticed with the cleaner floor.

In a large printing shop and bindery the superintendent insists on a clean shop. The men whose duty it is to prepare the glue at one time insisted that their room could not be kept clean because glue stuck so to the walls and floor. The superintendent ordered the whole room painted white so that they could clean any spattering of glue before it had time to dry. This removed the only excuse for a dirty shop. This plant specializes in high-grade printing and, according to the superintendent, could not maintain this quality if it were not due to the high standard of cleanliness and neatness required in the shop. After all, human nature is about the same everywhere and if you can't get around peculiar notions one way, try another. It will be more effective and less disagreeable than the "bawling-out" treatment.

Maintenance Is Not a Second Fiddle

PROPERLY maintained equipment never wears out and replacement of it is only occasioned by obsolescence, inadequacy, change in art, or economies and improvements. Facts to support this statement were given aplenty in the hearing on depreciation before the Interstate Commerce Commission last Winter.

Mr. L. F. Love, President of the Delaware and Hudson Company states in his testimony: "Depreciation postulates that anything to which it is applicable has a limited and calculable useful life, at the end of which it must be scrapped. There is no limit to the useful life of a composite railroad property. If the theory of depreciation is carried to its logical extreme, there is nothing left for repairs; if repairs are adequately made, there is no depreciation."

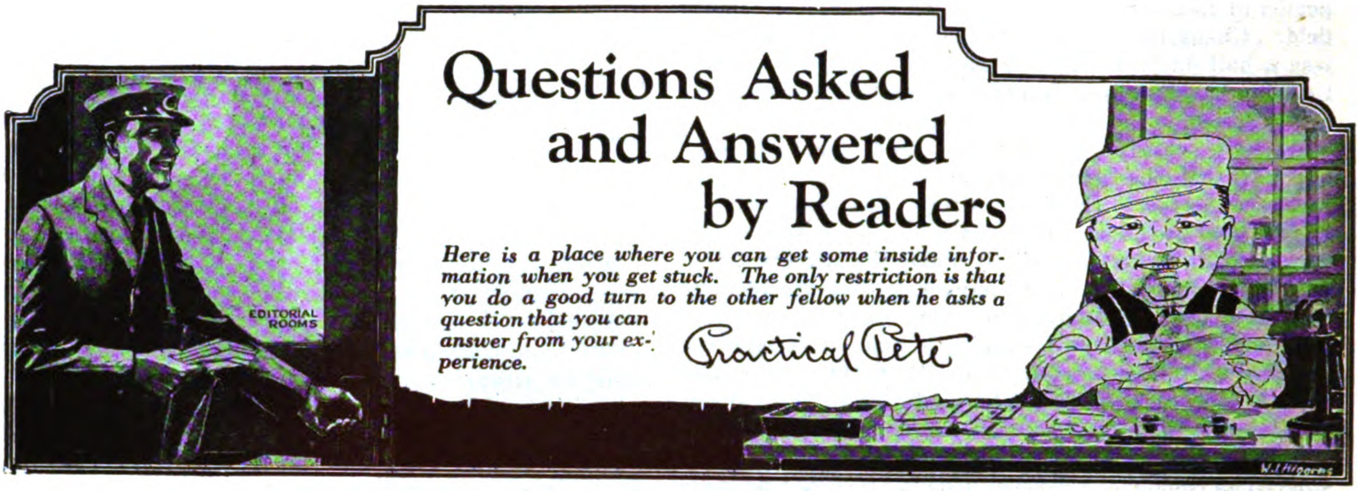
Mr. Sidney Z. Mitchell, President of the Electric Bond and Share Company, made a similar statement in his testimony. Mr. Alex Dow, President of the Detroit Edison Company, also testified that: "Generators have an indefinite life, with ordinary maintenance."

The late Robert A. Carter, Vice-President of the Consolidated Gas Company, in an address before the National Electric Light Association on Dec. 14, 1923, expressed his ideas regarding maintenance as follows:

> "Unlike human life, which is limited, the product of human energy may have perpetual life. The sphinx, the pyramids, celebrated obelisks, aqueducts, bridges and other structures, as well as statuary, jewelry and articles of personal and domestic use and adornment have survived and will continue to survive for centuries. They represent nothing more than a rearrangement of indestructible matter. If Quintus Marcius had constructed a gas plant or an electric plant instead of an aqueduct in 144 B. C. nothing but neglect would interfere with its operation today. And, even though neglected, so much of the plant as consisted of steel, iron, concrete, stone, brick and mortar, which would represent nearly 100 per cent of the cost, would remain in substantially its original form. Stephenson's second locomotive was still in use in 1922. The cast-iron water pipes leading from the river Seine to the fountains at Versailles were installed in 1658, and the only repairs that have been necessary after two and a half centuries of service are the occasional replacing of bolts. Rome is still supplied with water by an aqueduct the construction of which was begun by Quintus Marcius in 144 B. C. Tunis is now supplied by an aqueduct built by Hadrian in A. D. 120. The aqueduct at Nimes has been in use for nearly twenty centuries. There are many other instances of masonry and concrete structures which have survived many hundreds of years of useful service.
>
> "It is idle, therefore, to talk about the life of a utility's plant and equipment. The only matter of interest is its *maintenance in efficient service* by repairs, and its improvement by renewals and replacements to keep abreast of the development in the science of rendering utility service and to meet the growing demands of an increasing patronage."

Expressions like these put a different value on maintenance work than is commonly given to it. The usual plant manager expects his maintenance department to keep his machines running for ten or twelve years, when they will be replaced with new ones. Proper and adequate maintenance, according to the authorities quoted, would make these machines run forever. However, to attain this result in the industrial works high standards of maintenance will have to be attained—maintenance must not always play second fiddle to production and the maintenance men should receive the recognition they deserve.

To those interested in depreciation a booklet published by the Consolidated Gas Company of New York City, containing abstracts of testimony before the Interstate Commerce Commission, will be of interest.



Who Can Answer These?

Alarm System to Indicate Hot Bearing—We have had considerable difficulty on some heavy pressure rolls due to bearings getting too hot before they were discovered. I have heard that it is possible to use an alarm system of some sort for indicating when bearings get beyond a certain temperature. Can any readers tell me how a device of this sort may be made and installed?
Gary, Ind. L. M. C.

* * * *

Card System for Miscellaneous Power Drive Equipment—The only storage space we have for miscellaneous pulleys, shafting hangers and similar parts is some distance from the room which serves as the repair shop and headquarters of the maintenance department. As we now have no system of keeping track of this material one of the men must go and search through it whenever anything is needed. I should like to know if any reader has worked out a card system that we could use to tell what we have on hand.
Kansas City, Kan. H. L. G.

* * * *

Selection and Application of Carbon Brushes—Can any of the readers of INDUSTRIAL ENGINEER give me any information on how to choose and properly apply the various grades of carbon brushes? I should like to know how a practical man can by inspection and simple tests choose a suitable brush for a job or determine what application a certain brush is most suitable for. I have seen references to the electrolytic action between brass collector rings and carbon brushes and should like to know the cause of this action and if there are any means of overcoming it.
W. A. P.
Smooth Rock Falls, Ont., Can.

* * * *

Testing Large D.C. Generators for Short Circuits—Will some one give me a good, practical method of testing for short circuits, large d.c. generators and motors, especially those having equalizers or cross connections? I have in mind machines of 1,000-hp. rating and over. In the various articles on testing which I have read, I have failed to find any mention of these connections and should like to know the procedure when testing out a machine which has them.
Ottawa, Canada. S. J.

* * * *

Grounding Secondary of 3-Phase, 220-440-Volt Distribution System—I wish some reader would tell me whether the secondary of a three-phase distribution system for 220-volt and 440-volt motors should or should not be grounded? Why? The Standard Handbook says: "The grounding of secondaries up to 150 volts has been required by the National Electrical Code since 1913. There is some doubt as to the advisability of grounding secondaries when the difference of potential between any wire and ground is higher than 250 volts, owing to the possibility that shocks from such a system may prove fatal." How could a person receive a shock from a grounded secondary system when the conduit inside of the building is also grounded? Would not trouble at once reveal itself? I shall appreciate it if you can enlighten me on the why's and where's of this subject.
Orlando, Fla. H. C. M.

* * * *

Will This New Winding Be Satisfactory?—I have a 2,200-volt, three-phase, 60-cycle, 20-hp. motor that I want to rewind for 220 volts, three-phase, 60 cycles. This is a squirrel-cage motor, having seventy-two slots. The original winding was seventy-two coils wound with twenty-six turns of No. 19 wire, two-parallel, connected series star, the coils laid in slots 1 and 10. Would a winding consisting of thirty-six coils of sixteen turns of No. 14 wire, three-parallel, coil span 1-and-16, be satisfactory? How should this winding be connected? I shall appreciate it very much if someone will help me out on this.
Albany, Ga. B. B.

Answers Received To Questions Asked

Does Voltage Above Normal Affect Power Bill?—We buy power from a local power company at a line voltage of 13,000 volts. The voltage in the plant is supposed to be 550, but we have an average voltage of 640 to 700. Our motors are of the induction type, ranging from 1/10 to 50 hp. Will there be any loss of power with the voltage higher than normal? If so, what will it amount to? When the voltage jumps from 620 to 700 our indicating wattmeter will rise around 200 watts. Will this increase the reading of our kw.-hr. meter in proportion, or what per cent will it be? I have been checking very closely the power consumed and find that when we have high voltage the power runs higher also. I shall be very grateful for any information you can give me.
Rock Hill, S. C. L. W. M.

Replying to L. W. M., in the April issue, it is practically impossible to give anything more than a general answer to his question, as the effect produced by voltage higher than normal depends a great deal on the electrical design characteristics, of a motor.

As a general statement, it can be assumed that an increase in the impressed voltage will cause an increase in the input wattage of the motor, in proportion to the square of the impressed voltage. Just how close this approximation will be, will depend upon the design of the motor. L. W. M. says that an increase of 200 watts resulted from a change of voltage from 620 to 700, but no comparison can be made in the absence of the initial reading of the meter before the change in voltage.

If the motors are rated at 550 volts and the actual voltages vary from 620 to 700, or 12.07 per cent to 27.3 per cent it may even be possible with closely designed motors to have increased losses, or in other words, increased power consumption for the same load, which may vary in greater proportion than the ratios of the squares of the impressed voltages. The design of the modern motor is based on its performance at a certain rated voltage.

Assuming the motor load to be constant, an increase in impressed voltage will increase the exciting current and the iron loss, and decrease the load current. The decrease in the load current may offset the increase in the exciting current for a very small increase in the impressed voltage, but for increases of more than 10 per cent, the exciting current in modern motors increases very rapidly. The iron loss increases very rapidly for all voltages above normal and is much greater than the increased copper loss, due to a higher current.

C. OTTO VON DANNENBERG.
The J. J. White Engineering Corp.,
New York, N. Y.

* * * *

In answer to L. W. M.'s question in the April issue of INDUSTRIAL ENGINEER, I would say that increased voltage increases the current in the stator, in addition to lowering the power factor and decreasing the slip. It will, in all probability, cause a temperature rise due to increased current in the stator. Now to get to the question, Will there be a greater power loss with a higher voltage?, the answer probably is yes, although this would depend, to a large extent, upon the proportion of primary copper loss and iron loss in a normal machine, and also the degree of saturation in the iron.

I notice that you are using an indicating wattmeter, as well as a recording wattmeter. I assume that you have no power factor meter and use the indicating wattmeter to determine the power factor. Nevertheless, the recording wattmeter reading increases in proportion, since they both get the

same voltage and current. I do not know whether you can do anything to reduce the voltage to its proper value, but if you can, I would do so, for, as a general proposition, induction motors operate at their highest efficiency at the current and voltage given by the manufacturer on the nameplate.

SGT. JAMES A. COOKE.
Observation Battery,
Fort Bragg, N. C.

* * * *

Trouble With Single-Phase Induction Motor—Can some of the readers of INDUSTRIAL ENGINEER tell me what is the matter with a small, single-phase induction motor which fails to start when the switch is closed? Both the main and starting windings and the centrifugal switch have been tested and seem to be all right. After closing the line switch and giving the rotor a quick start by means of a string, the rotor will sometimes quickly come to a stop, or apparently lock. Then, possibly the next time the switch is closed the motor will start from rest and run normally. This is a standard make of four-pole, 60-cycle, 110-volt motor. I shall certainly appreciate any suggestions you can give me as to what is the trouble and how it can be remedied.
Urichsville, Ohio. R. F. P.

Replying to the question asked by R. F. P. in the April issue, these motors are manufactured in large quantities and the air gap is not given the attention that the larger motors receive. If he puts the rotor in a lathe and takes off 0.001 in. he will not have any more trouble from the rotor locking and failing to start. The air gap clearance in these motors is small and the rotors are not perfectly true, so that at certain positions the rotor may lock magnetically. Then the motor will burn out if the current is not switched off, or the fuse does not blow.

Chief Electrician, EARLE N. DILLARD.
Booth-Kelly Lumber Co.,
Springfield, Ore.

* * * *

In answer to R. F. P. in the April issuer, I would suggest that he test his starting winding leads by cutting out the switch and holding one side of the starting winding in his hand, with the other side connected to the running winding. Then close the line switch at the same time, having both windings connected across the line. After the motor stars, break the starting winding with the lead he holds in his hand. If the motor works satisfactorily he will find that the trouble is in his centrifugal switch. I believe this test will clear up the trouble that he is experiencing.

Albany, Ga. B. BELCHER.

* * * *

In reply to R. F. P.'s question in the April issue, I believe the motor he refers to has badly worn bearings, as this condition would cause the action that he describes. He might make a thorough examination to ascertain if the motor has any of the following defects, which may be easily determined by careful testing:

The starting coil may be short-circuited or burned out, likewise the running winding; these windings may be short-circuited together at some intermediate point as well as at one end. There may be two grounds in either winding, or one on both, which would constitute a short circuit. There might be an opening in the starting winding which makes enough contact occasionally to start the motor; this would cause the intermittent starting described. This opening could be in the centrifugal switch; that is, the springs that hold it closed may have lost their tension.

I do not think that the rotor is open, although it might be examined for loose bars. These small rotors give very little trouble.

Electrician, G. H. EMERSON.
Electric Repair & Service Co.,
Birmingham, Ala.

* * * *

Answering R. F. P.'s question in the April issue of INDUSTRIAL ENGINEER, if he is sure that the starting and running windings of his motor are O. K., and that the centrifugal starting switch is operating properly, he will probably find that the trouble he describes is due to worn bearings. Small induction motors have only a small clearance between the rotor and stator, and even slightly worn bearings will sometimes let the rotor drag, thus "locking" the armature when starting the motor.

We service a number of these motors driving electric pianos and in most cases find that when they begin to fail to start at times, the bearings need renewing. R. F. P.'s motor starts part of the time, due to the fact that the lubricant in the bearings sometimes forms a film sufficiently thick to raise the rotor clear of the stator. I hope that this suggestion will help him to remedy his trouble.

San Angelo, Tex. S. CURTIS EBNER.

* * * *

Effect of Armature Coil with Reversed Polarity—Sometime ago this question was raised in our shop: Will a reversed polarity coil in an armature burn out while running or what effect will it have on the armature?

I contend that in order to burn out a coil a heavy current must flow in that coil, which could only be caused by a short circuit. As all coils are connected in series, current of the same amount would flow in each; if one were reversed it would oppose the action of the others and having only the same amperage through it as the others it could only oppose with the strength of one coil, and would neutralize one armature coil.

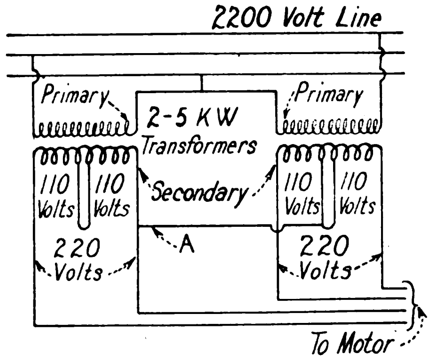
I should like to hear from some of the readers of INDUSTRIAL ENGINEER on this question.
McKeesport, Pa. E. K.

In reply to E. K.'s question in the February issue, the coil will not burn out while running but it may cause unsatisfactory operation by bringing about an unstable magnetic condition of the armature. The latter will have two or more paths in parallel, depending on the number of poles and the type of winding, and inasmuch as the reversed coil opposes the remaining coils of the group of which it is a part, there will evidently be two less effective coils in the one group, as the reversed coil neutralizes one other coil, than there are in the remaining group or groups.

The amount of magnetic unbalance will be in proportion to the number of coils in the group. The effect on the operation of the motor will be an unbalanced torque, sparking at the brushes and a rise in the temperature of the armature.

Muncie, Ind. GEORGE CROPPER.

Trouble in Operating Two-phase Arc Welder Set on Three-phase Circuit—I had occasion recently to operate a two-phase, four-wire, 220-volt, 60-cycle, 1,800 r.p.m. 5-hp. Lincoln motor, which is direct connected to a Lincoln welding generator on a three-phase, 2,200-volt, 60-cycle circuit. The transformer connection shown was tried. I found that the motor would start but in a short time would get very hot. The wire at *A* was cut and then the motor did not heat so much, so that by stopping the machine about every hour and letting it cool off I was



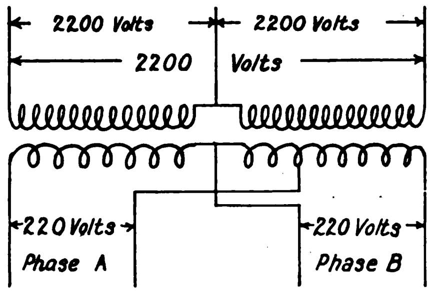
able to do the welding, but too much time was lost. I wish some of the readers of INDUSTRIAL ENGINEER would tell me if this connection is correct, and if so, what causes the motor to heat.
Tyrone, Pa. H. L. F.

In answer to the question by H. L. F. in a recent number, the connection which he is using is wrong, as he is in reality obtaining two single-phase currents which are not at right angles to each other. I would suggest that if one of his transformers does not have a tap on the secondary side which will deliver a voltage equal to 90 per cent of the voltage of the other transformer, he trade it for one which is provided with such a tap.

Assuming it is possible for him to get at the center of the secondary of the remaining transformer, the use of what is known as the Scott connection, which can be found in any handbook, should solve his problem very satisfactorily.

It may be difficult, or impossible, for him to make this exchange of transformers, or too much trouble, if the welding outfit is for temporary use only. In this event I would suggest that he use, as an emergency method, the connection shown in the accompanying diagram. This will not give a balanced condition but the results will be much better than with the present connection and there is the further advantage that the transformers now on hand may be used.

Clarkdale, Ariz. T. E. PEACOCK.



Emergency connection of transformers for obtaining 220 volts, two-phase, from 2,200-volt, three-phase circuit.

Correcting Power Factor by Synchronous Condenser—I wish to submit the following problem to our readers: *A* is a distributing station supplying power to four feeders, *B*, *C*, *D* and *E*; *B* takes 4,000 kw., *C*, 3,500 kw., *D*, 3,000 kw., and *E*, 2,000 kw. The power factor of these loads is: *B*, 80 per cent, *C*, 78 per cent, *D* 75 per cent and *E*, 72 per cent, all lagging. It is desired to install a synchronous condenser at station *C*, to give 95 per cent power factor. Would it make any difference in the size of condenser required at *C* if stations *B*, *D*, and *E* were to correct their power factor to unity instead of running at 80, 75 and 72 per cent respectively, as at present, (1) in case station *A* has ample generator and exciter capacity and (2) in case this capacity is just enough to carry the load?
Belleville, Ont., Can. J. H. G.

The question asked by J. H. G. in a recent issue of INDUSTRIAL ENGINEER presents an interesting problem. Neglecting the reactance of the distribution lines, which would probably be small in any case, we have a resultant lagging power factor of 77 per cent at station (A), determined as follows:

Feeder	Load in kw.	Power Factor	Load in kva.
B	4,000	80 per cent	5,000
C	3,500	78 per cent	4,487
D	3,000	75 per cent	4,000
E	2,000	72 per cent	2,778
	12,500		16,265

Kilovolt-amperes are determined from the formula, $\text{Kva.} = \frac{\text{Kw.}}{\text{P. F.}}$ Then for total load $\text{P. F.} = \frac{\text{Kw.}}{\text{Kva.}}$ or $\frac{12,500}{16,265} = 77$ per cent.

From this it will be seen that the total electrical capacity necessary at station (A) to supply these four feeders is 16,265 kva.

In installing a synchronous condenser at station (C) for correcting power factor, two courses are open. The first is to install a condenser of the proper size to raise the power factor of station (C) only, from 78 per cent to 95 per cent lagging. The second is to install at station (C) a condenser of such a size that it will have a leading power factor of a value to counteract the lagging power factor of the other three feeders and give a resultant power factor at station (A) of 95 per cent lagging. The first course will benefit station (C) but the benefit to station (A) will be small, as it can be shown, by calculations similar to those given above, that if the power factor at station (C) is raised to 95 per cent the resultant power factor at station (A) will be raised only to 81 per cent and the electrical capacity required decreased to 15,462 kva.

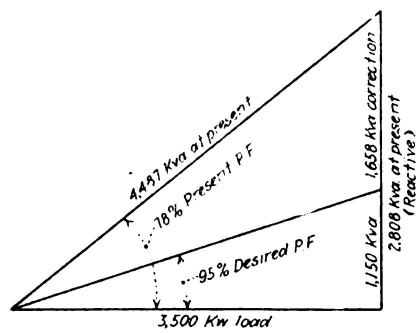
On the other hand, if a large enough condenser is installed at station (C) to bring the power factor at station (A) to 95 per cent lagging the electrical capacity required at the latter will decrease to 13,158 kva.

To determine the size of condenser for the first case, we have 3,500 kw. at 78 per cent power factor. The desired power factor is 95 per cent.

$$\text{Present kva.} = \frac{3,500}{.78} = 4,487 \text{ kva.}$$

Present reactive kva. $= \sqrt{4,487^2 - 3,500^2} = 2,808$ kva. Kva. at the desired power factor $= \frac{3,500}{.95} = 3,684$ kva. Reactive kva. at the desired power factor $= \sqrt{3,684^2 - 3,500^2} = 1,150$ kva. Then the corrective effect needed $= 2,808 - 1,150 = 1,658$ kva. The illustration will help to make this clear.

In a similar manner the corrective effect needed at station (C) to bring the power factor at main station (A) to 95 per cent will be found to be approximately 6,200 kva.



Graphic method of determining size of condenser needed for power-factor correction.

The size of condenser required at station (C) will be independent of the power factor at stations (B), (D) and (E), insofar as station (C) itself is concerned, but the effect of partial or total system correction will affect station (A), as has been shown. In case station (A) has ample generator and exciter capacity to carry the kva. load, the effect of power factor correction at one of the other stations is to reduce the line losses and heating and to improve the voltage regulation. If station (A) has only enough capacity for the kw. load, then either correction of the power factor of the whole system or the installation of additional capacity at station (A) must be resorted to.

It will be noted that the total load in kva. has been calculated from the arithmetical sum of the individual kva's. This is not strictly correct as the total kva. is actually the vectorial or geometric sum of the individual kva's. However, since the power factor of the individual loads does not vary by more than a maximum of 8 per cent, the error introduced by taking their sum is negligible.

The attention of J. H. G. is directed to the very excellent article on Power Factor by Mr. E. H. Hubert, that appeared in the December, 1922, issue of INDUSTRIAL ENGINEER.

Comerio Falls, FREDERICK KRUG.
Bayamon, Porto Rico.

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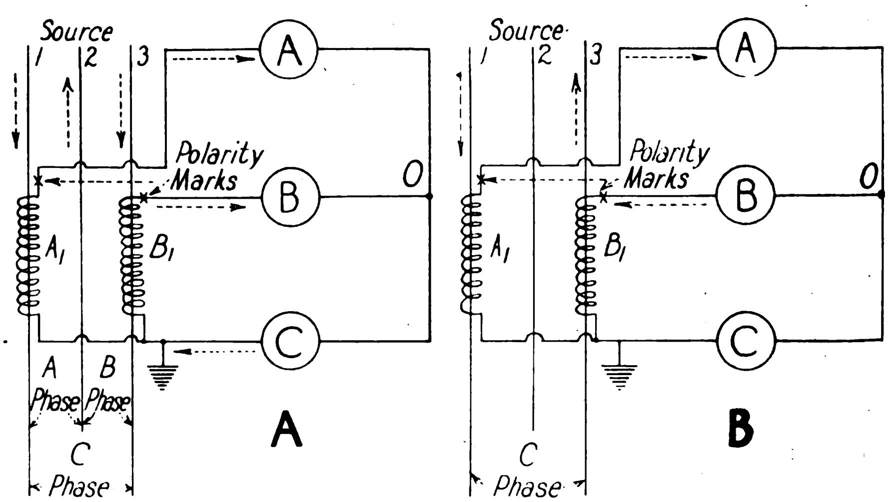
Ammeters Connected for Three-Phase, Three-wire Circuits—I wish some reader of INDUSTRIAL ENGINEER would give me a wiring diagram of three ammeters used on a three-phase, three-wire circuit, using only two current transformers, and explain how the current passes through each meter.
Haledon, N. J. G. Z.

In answer to G. Z. who asks in the August issue for a diagram and explanation of the method of connecting three ammeters to two current transformers on a three-phase, three-wire circuit, I wish to submit the following information:

This connection is known as the reversed "V" connection and is the one which is most frequently used for instruments of the indicating type.

First of all it is necessary that your transformers be connected up in accordance with their polarity marks. These polarity marks on instrument transformers indicate that with current flowing into the marked primary terminal at any instant the current in the secondary will flow out of the marked secondary terminal at the same instant. If we have a balanced three-phase load the three ammeters should, of course, all indicate alike, and there will be three equal currents, circulating in the three main wires, but their maximum and zero values will differ by 120 electrical degrees. However, to make the explanation clearer, we will assume an instant when the conditions are as shown in (A) of the drawing, where the current in No. 2 wire is maximum in a certain direction and the current in both outside wires, Nos. 1 and 3, is equal and one-half the value of the current in No. 2 wire, but in the opposite direction. Ammeter (A) indi-

Instantaneous direction of current flow in a system of three ammeters and two current transformers on a three-phase, three-wire circuit.



cates the current in line No. 1; ammeter (B) the current in line No. 3; and ammeter (C) the current in line No. 2.

The direction of the currents in the transformers will be as shown in (A), the current from transformer (A_1) flowing through ammeter (A), and current from transformer (B_1) flowing through ammeter (B). Now since the currents in the primary of both transformers are equal and in the same direction, the current in the secondaries of both transformers will be equal and in the same direction and meters (A) and (B) will give the same reading. These two currents unite at (O) and together flow through ammeter (C), which will show a reading twice that of (A) or (B), thus showing that No. 2 wire carries twice as much current as wires No. 1 and 3. However, at another instant we may have No. 1 and No. 2 wires carrying equal currents and the current in wire No. 3 would be double and opposite in direction, so that the current from the secondary of transformer (B_1) will be double and in the opposite direction to the current from the secondary of transformer (A_1). Therefore the reading of ammeter (B) will be twice that of ammeter (A). Then these two currents will join at (O), but since the current in (B) is double and opposite to the current in (A), we will have the difference, or a current equal to that flowing through ammeter (A), flowing through ammeter (C). However, the meters could not respond to these rapid changes in current value, but will indicate the effective value of the current in the line and if these currents are equal, then the three ammeters will all indicate alike.

We may also take an extreme case of unbalanced load where a single-phase load is placed on phase (C), as in (B) of the diagram. Now the current in line No. 2 will be zero, but that in lines Nos. 1 and 3 will be equal and opposite in direction. Current will flow from the transformer secondaries, (A_1) and (B_1) as shown and ammeters (A) and (B) will both indicate alike. But the current from (A_1) tends to flow through ammeter (C) in the opposite direction from which the current from (B_1) tends to flow, and since both these currents are equal and opposite they neutralize each other and therefore ammeter (C) gives no reading, thus showing zero current in line No. 2.

ERNEST DICKINSON.
Kimberley, B. C., Can.

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What Causes This Motor to Spark at the Brushes?—I have a 35-hp., four-pole, shunt-wound motor that drives a fan. The armature has seventy coils, lap-wound. Under load this machine draws 280 amp. at 115 volts and has always sparked viciously. The brushes are of the Bayliss type and I find the neutral point with a voltmeter as closely as one can. When I stone the commutator down the motor runs satisfactorily for a day or so and then sparking begins and the commutator develops low bars and seems to flatten or sink.

I am wondering if this armature was designed for a four-pole machine, as it has seventy bars and coils. This number is not divisible by four without a remainder and thus throws the neutral point in the center of a bar. I shall be very grateful if some reader can explain what causes the sparking and tell me how I can overcome it.

New York, N. Y. C. E. K.

In answer to C. E. K., in the March issue, I have had similar trouble with a motor sparking at the brushes and the commutator bars sinking and becoming flat. In my case, the cause was found to be due to the fact that the motor had run hot which caused the cone of mica that wedges up the bars to loosen slightly. The bars in time loosened somewhat, thus allowing the mica to work out from between them. After a few hours running, the mica came over the bars. This was the cause of sparking.

When the commutator was stoned, it would run satisfactorily until the mica came out again, which it would do in a short time. Tightening the commutator and turning it down on the lathe cured the trouble.

Liege, Belgium. P. VAN HERK.

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In answer to the questions asked by C. E. K. in the March issue of INDUSTRIAL ENGINEER, I believe that the trouble is caused by high mica; if the commutator were undercut, this trouble would be eliminated.

Undercutting can be done with a hacksaw blade, cutting the mica down between the segments not more than 1/32 of an inch. A better way of doing this, however, is to use a three-cornered file as this leaves a V-shaped groove that is easier to clean.

Another possible cause of trouble may be a loose commutator. The commutator may be tightened by screwing up the endplate which generally has a right-hand thread. After doing this, the armature should be tested for short circuits as the insulation may be damaged when the commutator is tightened.

Maintenance Electrician, PAUL FEENEY.
General Electric Company,
Lynn, Mass.

* * * *

In reply to the question asked by C. E. K. in the March issue of INDUSTRIAL ENGINEER, his motor is carrying 23 per cent overload. If the brushes do not have enough contact area to carry the current this will cause sparking, which will gradually grow worse as the commutator blackens. The remedy is to increase the size of the brushes in width. If there is not room to do this, change the type of brush to one that has a greater carrying capacity.

Other and more serious causes of sparking are: open or short-circuited armature coils; short-circuited segments; coils grounded; sprung shaft; pulley out of true; loose bearings; commutator not true; brushes not set diametrically opposite. Low commutator bars are caused by the mica V end ring coming loose and allowing the segments to change their position. Tightening the end ring and truing the commutator in a lathe will remedy low bars.

Chief Electrician, EARLE N. DILLARD.
Booth-Kelly Co.,
Springfield, Oregon.

* * * *

In the March issue C. E. K. asked why his 35-hp. motor sparks unduly. In the first place the machine is pulling about 37½ hp. An overload that is on continually is not good for any motor. A commutator will pit and blacken from several causes. For example, a ground on some other part of the motor will do this. If the mica does not wear down with the copper, the brushes will spark badly and cause black spots on the commutator. To remedy this, undercut the mica.

Vibration of the motor foundation and worn bearings are also causes. Likewise, if the commutator is worn into grooves where the brushes ride, too much end-play will cause sparking. The armature described by him is very comman in Crocker-Wheeler motors and works very satisfactorily.

Sometime ago, I had a peculiar experience with a commutator which continually blackened. We found at last that another motor on the same service from the switchboard had a grounded brush holder, but it did not spark. When this brush holder was repaired the commutator of the other motor did not blacken up any more.

Peoria, Ill. GEORGE RINGNESS.

* * * *

In regard to C. E. K.'s question in the March issue, he states that the motor runs well for a few days after the commutator has been turned. I think this shows that the trouble has been caused by hard and high mica. The mica, being harder than the copper, will not wear down at the same rate as the latter and has a tendency to keep the brushes from making good contact on the commutator; therefore sparking will result. I have found this to be a very common trouble in old-time machines.

One way to remedy this is to increase the tension on the brushes and use harder carbon. The best way, however, is to undercut the commutator; this can be done very easily with a hacksaw blade. Cut away the mica for about 1/32 in., below the surface of the copper. Readjust the tension on the brushes to 2 or 3 lb. per square inch of carbon. Have all brushes pig-tailed. I hope these suggestions will help C. E. K. to overcome his trouble.

San Francisco, Calif. P. P. SCRIBANTE.

* * * *

Answering C. E. K.'s question in the March issue, he states that a 35-hp. shunt-wound motor draws 280 amp. under full load and is a 115-volt motor. This motor is therefore working at a fair overload. I would suggest that he undercut the mica in the commutator as stoning a commutator only cuts the mica flush with the copper bars. As a rule, therefore, it serves only to stop sparking of the brushes temporarily.

I would also suggest that he sand the brushes and see that they are properly seated on the commutator. Also, I would advise him to check up on the following conditions, as possible sources of his trouble: Brushes out of line, brushes must be kept on the ¼ or ⅙ or ⅛ according to the number of field coils in the motor; worn bearings or vibration in the armature on account of the latter being out of balance.

I hope that this information will help C. E. K. to stop the sparking in his motor.

Shreveport, La. GUSTIN R. LIEBER.

In reply to the question asked by C. E. K. in the March issue, from the data given 280 amperes times 115 volts equals 32.2 kw., or 32,200 divided by 746 equals 43.16 hp. The full-load capacity of a 35 hp. motor at 115 volts is (35 × 746) divided by 115 equals 227 amp. Then 280 minus 227 equals 53 amp., or 25.5 per cent overload on the motor.

Since the motor ran satisfactorily for a few days after grinding, it proves that the armature is properly designed. In my opinion the cause of sparking is inability of the brushes to carry the current in excess of what the motor was designed for. This in turn carbonizes the surface of the mica segments, causing partial shorts in the commutator. I would suggest applying a larger motor, or decreasing the load by reducing the speed of the fan.

WILLIAM J. MILDON.
Madeira Hill Coal Mining Co.,
Philipsburg, Pa.

* * * *

In the March issue, C. E. K. describes trouble experienced with a 35-hp. shunt-wound motor. I would advise him to take out the armature, heat the commutator thoroughly and tighten it while hot; then let it cool down and try to tighten it again. Now sound the commutator with a hammer and note very carefully whether the bars move. If they do, I would advise him to make new V-rings and repeat the process of tightening. Then put the armature in a lathe, turn the commutator and undercut it.

The brushes should receive attention next. They should not cover too many bars as this will cause sparking, nor should they cover less than 1½ bars. Also check up and see that there is enough carrying capacity in the brushes. For 280 amp. there should be at least 7 sq. in. of carbon brush contact on two of the four brush studs.

Make sure that the armature is balanced, as flat spots on the pulley or unnecessary bumps in the belt lacing, or uneven air gaps will also cause sparking.

NICHOLAS J. WEISS.
West New York, N. J.

* * * *

Transformer and Balancer Coil Connections—In our plant we are operating one 50-hp., one 30-hp., two 5-hp., and two 2½-hp. three-phase, 60-cycle, induction motors. The lighting load, single phase, amounts to about 10 kw. I wish some reader of INDUSTRIAL ENGINEER would give me a diagram showing how to connect three 5-kva. single-phase transformers and balancer coils to obtain 110-volt single-phase current for lighting from the 220-volt, three-phase line from our alternator. Will you also show me how to cut in on the power company's transformer in case our machine should get out of order, and how to cut out their meters and transformers both at the same time when our machine is ready to be put in service again.

Detroit, Mich. O. C. H.

Answering O. C. H. in the January issue, if you wish to keep the 220-volt, three-phase circuit balanced there is no connection that will meet your requirements. I should like, however, to offer some suggestions that may be of help. I assume that you have a 220-volt primary, 110-220-volt secondary, three-wire balancer coil. As a balancer coil is designed to take care of the unbalanced load on a 220-volt, three-wire distribution system, having a 220-volt, two-wire primary, there is no need of using three 5-kva. transformers on the lighting circuit. If it is desired to keep the 220-volt, three-phase circuit nearly balanced, I would suggest that you use two balancer coils and two 110-220-volt, three-wire lighting circuits, of 5 kw. each. Fig. 1 shows the method of connection which should be employed. If you do not wish to use the balancer coils, connect two 5-kva., single-phase transformers open delta, and run the three-phase, 110-volt circuit to your cabinet box, and divide the lighting load between phases so as to keep them as nearly balanced as possible.

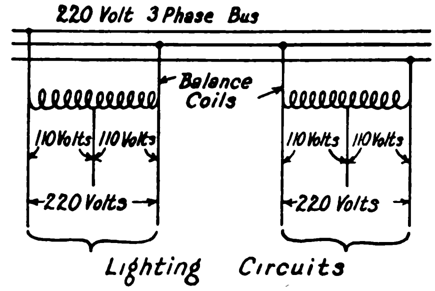


Fig. 1—Two balancer coils connected to a three-phase circuit to give two 110-220-volt, three-wire lighting circuits.

You also ask for a method of connecting the central station lines to your motor circuit in case your alternator gets out of order.

Fig. 2 shows a method of connection which I think will prove satisfactory. In proposing this method of connection I have assumed that the motors may be shut down long enough for the necessary switching to be done.

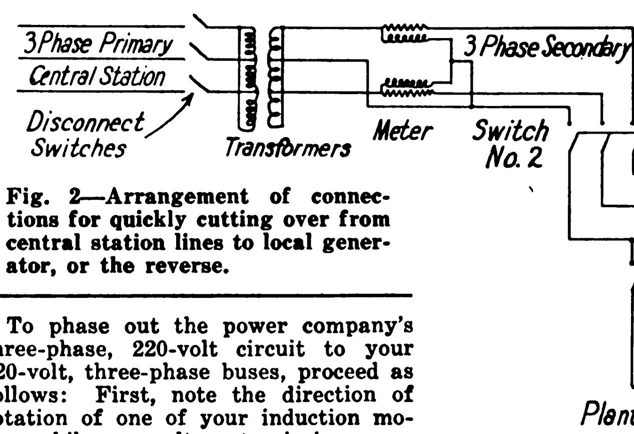


Fig. 2—Arrangement of connections for quickly cutting over from central station lines to local generator, or the reverse.

To phase out the power company's three-phase, 220-volt circuit to your 220-volt, three-phase buses, proceed as follows: First, note the direction of rotation of one of your induction motors while your alternator is in operation. Stop the alternator and pull switch No. 1 (shown in the diagram), and then throw your switchboard bus on the line by closing switch No. 2, and then disconnect switches ahead of the transformer. Start the induction motor and if it runs in the same direction as formerly your connection is correct. If the motor runs in the opposite direction, change any two of the central station leads at the bus.

Do not attempt to put your alternator back on the circuit before opening the power company's switch (switch No. 2) as the alternator is probably not synchronized with the power company's line. Then cross currents would flow between these lines and the alternator and probably cause considerable damage to the alternator or transformers or both.

If you do not want to stop your motors while changing from the power company's circuit to your alternator, or vice versa, you can install a synchroscope, synchronizing with lamps is not very reliable, and parallel the alternator with the power company's circuit in this way. When installing the synchroscope, consider the power company's circuit as an alternator. Full instructions and wiring diagrams accompany these instruments.

Galesburg, Ill. EARL BABER.

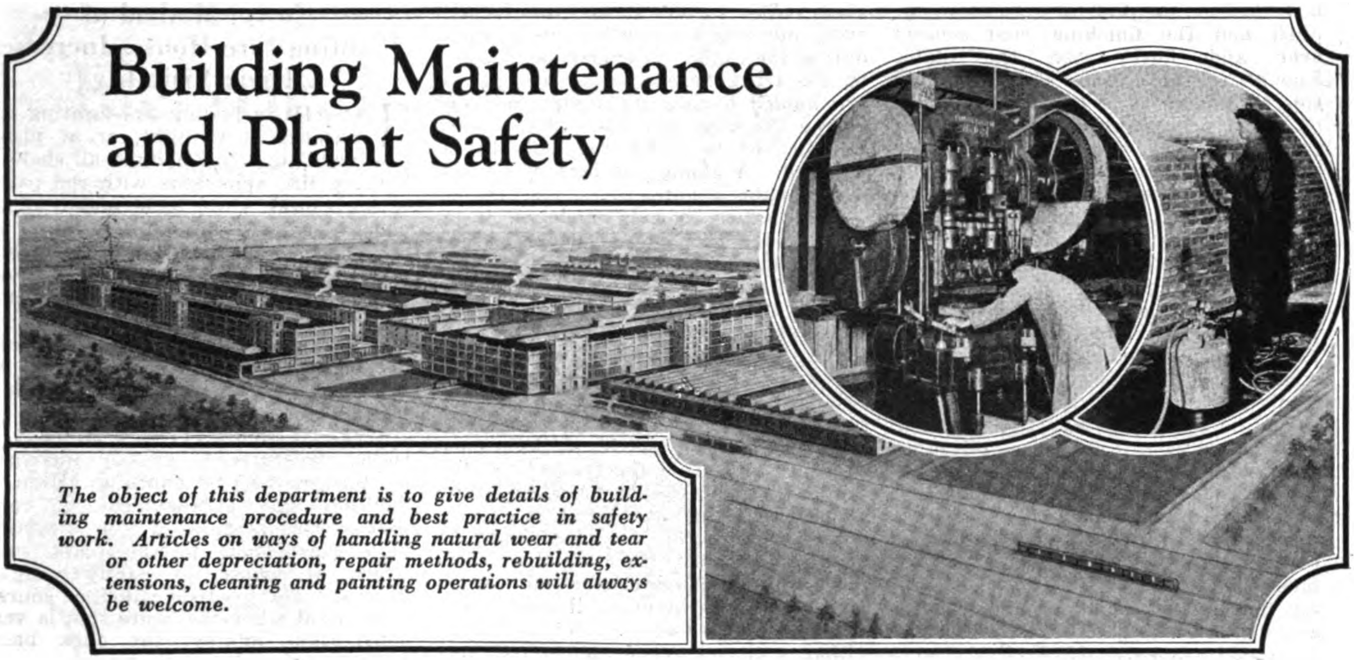
* * * *

I have noted the question by O. C. H. in the January issue, and want to say that his proposal to connect three 5-kva. transformers in the manner indicated, is not practicable. I suggest that he use two 220-volt, auto-transformers with 50 per cent taps to obtain a single-phase, three-wire, 110-220-volt lighting system. The transformers should be of 7½-kva. capacity each and connected open delta.

I recently wired a plant which generates its own power but is arranged to use central station power in case of emergency. The central station lines come in through the usual service switch and meter and were connected through a single-throw, fused switch to the three-phase bus on the plant switchboard. When this switch is opened it disconnects the power company's transformers and meters. It is only a matter of a moment, however, to open the plant generator switch and close the switch between the switchboard and the central station lines and thus operate the plant on central station power when necessary.

When I put in this installation I had, of course, to phase out the incoming power lines with the plant generator, which I did simply by testing one of the three-phase motors for rotation, first, when operating from the plant generator and then when cut in on the power company's line. On the first trial, the motor when operated on central station power rotated in the opposite direction to its usual rotation; then I transposed two of the incoming power lines and, on a second trial, the motor rotated in the proper direction.

Chicago, Ill. A. NOEPPEL.



Building Maintenance and Plant Safety

The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

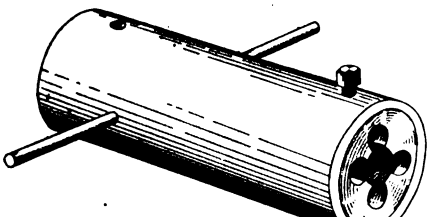
Simple Diestock Facilitates Rethreading of U-Clips

THE ever-increasing use of steel structures often brings the maintenance crew face to face with a new problem. In particular, shaft hangers, pipe lines, conduits, and a variety of interior fittings must be attached to steel shapes, and the methods of attachment differ widely from those employed in mill-construction buildings.

One of the commonest methods of attaching parts to structural steel, for permanent installations as well as for temporary set-ups, is by the use of U-shaped clips. The cost of such clips is low and they are so widely used that they can be made up in quantity and kept in the stockroom.

The only serious objection to U-clips comes from the men on the firing line—the men who have to take off existing clips, or put up others that have already been used. The men complain that the threads on the ends get battered up, particularly the threads extending beyond the nuts. To get a nut off over these damaged threads, or to start one on such an end, is not only vexatious and wasteful of time but it frequently results in spoiling the thread in the nut or clip.

With ordinary bolts, bruised threads may be chased over with a die in short order, but with clip threads, the presence of the other leg, full length, effectually prevents turning the die stock around—or at least turning it far enough down to do much good. It is customary to take such clips to the blacksmith and have them partially straightened out; then they go back to the shop for rethreading and finally make another trip to the blacksmith for forging to the original shape. All master mechanics know of the loss in connection with this process.



With a diestock like this U-clips and stud bolts can be rethreaded without difficulty.

The simple diestock shown in the illustration can be made in the shop and will enable the task of rethreading clips to be done as quickly as similar work upon an ordinary bolt. As will be seen this diestock may be made from a piece of pipe or steel tubing, or it can be cut from a solid round piece. The valuable feature is in the extended body which places the die ahead of the handle by whatever amount is desired. The body should have a smaller inside diameter than the die in order that a recess can be bored out to fit the die and a shoulder cut for it to rest against.

A simple setscrew retains the die in position, its point dropping into the countersink provided for the purpose. For a handle a steel rod or a piece of pipe is inserted crosswise. As rethreading requires much less power than threading for the first time such a diestock need not be made as strong as the conventional ones and gratifying lightness results. This is a valuable feature because the stock may be used by workmen on a ladder or scaffold, where it is thus possible to rethread a clip without taking it down.

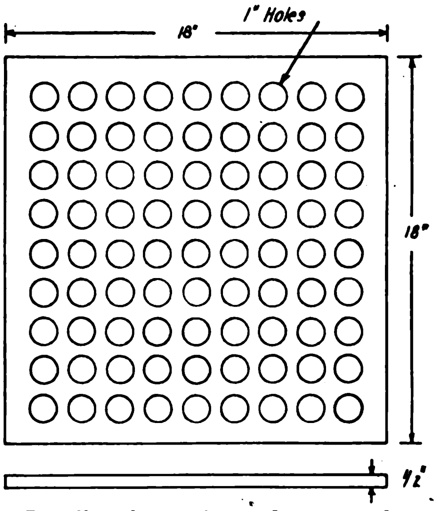
The class of work in the plant will determine how much offset the die should have, when making up such a stock. Because it is much easier to start a thread on a new blank when the die itself lies practically in the plane swept by the handles, the ordinary stock is made in that way—and that is the most satisfactory form for general work. However, occasions such as mentioned above do arise when considerable offset is desirable. Other uses will be found for this tool, among them rethreading cylinder studs without removing them. DONALD A. HAMPSON.

Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.

Repairing and Maintaining Worn Concrete Floors

OFTEN where concrete floors are subject to heavy trucking, the life of the floor is short. As the concrete usually wears in spots or in grooves, it makes for hard trucking. Our experience has given us the following methods of making repairs which we think are probably the best ways of prolonging the life of our factory floors.

When laying a new floor which we know will receive severe service, or where an old one has worn so much as to require entire resurfacing, we insert cast-iron slabs, as shown in the accompanying sketch. These slabs are 18 in. x 18 in. x ½ in., and perforated with 1-in. holes. With a simple pattern any plant with its own foundry can make them up at little expense. These cast-iron slabs are placed on the rough



Details of cast-iron plate to take the wear on concrete floors.

When new concrete floors are laid or old ones receive extensive repair and resurfacing, it often pays to add cast-iron floor plates such as this in trucking aisles where it is known that they will receive excessive wear. The pattern for such a plate is easily made and the plates may be cast at small expense.

floor before the finishing coat is applied and the finishing coat poured over and flush with the slabs. Enough of these slabs should be laid side by side so as to be over the width of the trucking aisle. A floor thus treated, we have found, will out-wear five ordinary floors.

In cases where a floor is badly worn and the expense of the above method is not warranted, a special mixture may be applied to the whole surface. This mixture consists of pitch, powdered asphalt and sand in the proportion of 1 to 17 to 18.5, respectively. This must be mixed quickly and applied while hot, as it sets rapidly. In order to give entire satisfaction, the mixture should be applied at least 1½ in. thick.

In cases where a floor is pitted in spots but is othewise in fairly good repair, the above mixture may be applied with good results if the surface to be treated is heated to a high temperature before the mixture is applied. One of the best ways of applying this heat is under pressure, as with an oil burner.

Electrical Engineer, H. E. STAFFORD.
Port Arthur, Ont., Can.

Adding Dump Body to Old Electric Tractor Rebuilt for Hauling Coal

SOME time ago we needed a small truck to haul coal to four annealing furnaces and it was decided to rebuild an old tractor which had for several years been used for hauling pig iron in the foundry. This tractor was strongly built and had given very satisfactory service. An examination showed that it was in such good condition that only minor repairs would be needed to fit it for the new service. These repairs consisted mostly in putting new rubber tires on the wheels and installing a new and larger battery.

The battery contains twenty Edison cells A6 size, 45-amp. rating, arranged in four trays of five cells each. A standard 24-volt motor fitted with ball bearings drives the truck. The connections to the battery and between the upper and lower trays are made with the Edison tray end terminal lugs. The cells are arranged ten below and ten above. The battery is exchanged early every morning for another one charged during the night. It cannot be charged on the truck because sand and refuse are hauled during the night and coal during the day; also the battery must be removed to allow the cells to be watered. A change of battery can be made in ten minutes.

The battery box is made of ⅛-in. steel plates with both ends removable by sliding them upwards. A steel partition in the middle supports the upper section of the battery. The battery box has a steel cover.

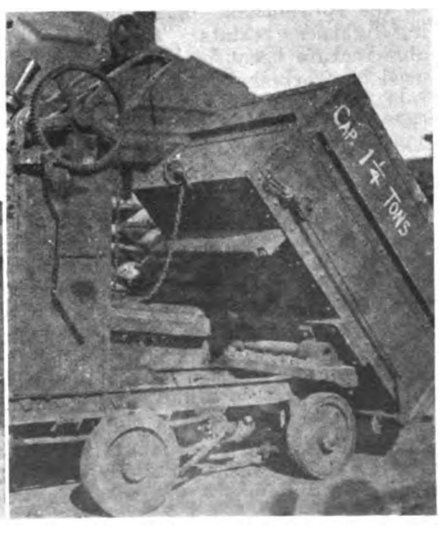
Also, some changes were made in the wiring which is now flexible, standard No. 6 oiled cambric with heavy braid, carried to the motor and switch in 1¼-in, rigid conduit tightly strapped along the inside of the frame. At the motor the six leads, two armature and four field leads, are terminated with copper lugs so that the motor may be readily removed for repairs. The leads enter the motor through watertight rubber bushings. All wiring connections are made extremely tight either with set screws or bolted lugs because of the heavy flow of current. All conductors running in parallel and exposed to the weather are tape covered and coated with asphaltum paint.

The most important alteration was fitting a steel dump body to the truck. This was made in the form of a strong steel box 4 ft. 6 in. long, 3 ft. 3 in. wide and 2 ft. 6 in. deep, reinforced along the upper edges and around the middle with angle iron. The front end of the body rests on a 2-in. pipe bearing which allows the body to be tipped for quickly unloading the coal by opening the front end which is hinged at the top. The rear end of the body is raised by a chain and hand windlass at the back end of the truck. The construction of the body and windlass is clearly shown in the accompanying illustration.

The truck as rebuilt weighs 2,600 lbs. unloaded. It has a capacity of 1¼ tons of coal and with this load it travels at the rate of 180 ft. per min. on the level. With an operator and a helper the truck has for some time hauled an average of 20 tons of coal, enough for four annealing furnaces, each working day. H. S. RICH.

New Britain, Conn.

A steel dump body raised at the end by a windlass was mounted on the tractor to fit it for hauling coal during the day and sand and other foundry refuse at night.



Novel Method of Painting Fire Houses Increases Their Visibility

TO AID in finding fire-fighting apparatus at twilight, or at night, one large plant has painted all shelters housing fire apparatus with red paint. A horizontal white band about 12 in. wide is painted around the center of the shelter. This is done to all shelters, shanties, outhouses or other small structures containing fire hose, chemical wagons or other industrial fire-fighting apparatus. Sand boxes and fire buckets are similarly painted. All fire hydrants are painted red with a white cap on the top.

It will be found that the visibility of these structures is greatly increased by this method of painting. Even in daylight this arrangement of color makes the location of the structure very conspicuous in the plant yard which, of course, is exactly what is desired. The greatest value, of course, is at night when the white spot is very conspicuous against the dark background.

Chicago, Ill. H. H.

How to Prevent Low Spots When Repairing Concrete Floors

IN OUR machine shop there was a good 6-in. concrete floor. When the floor was put down, about fifteen years before, it had been laid in 8-ft. sections across the shop. In the course of time these sections had separated slightly but not at all objectionably, except where the passing of trucks had chipped the edges of the sections in the aisles.

As our floor trucks carried loads up to one ton and were constantly moving, these innocent sections became gulleys that the wheels traversed with a bump —a bump that was risky for cast-iron wheels and that added considerably to the labor of moving the trucks about by hand.

As the corners were getting rounded further and further back, we decided on a repair. Now that the repairs have stood for two years, it is possible to speak of the results with the confidence of experience.

Where these gulleys were worn, we cut out the concrete to a depth of 2 in. or more, running the cut back to take out all of the round corner no matter if it did make a wider groove in some places than in others. The work was done in relays, doing so much on a Saturday morning and filling up with concrete that then had a chance to harden by Monday morning.

A sand-and-cement concrete was used. Before applying, the cut-outs were thoroughly wetted and the water given a chance to soak in. Instead of filling the cut up flush with the floor, they were trowelled off somewhat higher—about ¼ in. higher in the center. This was done to offset the shrinkage which occurs at such a repair and which unless allowance is made for it, will cause a low spot by the time it has been in a while.

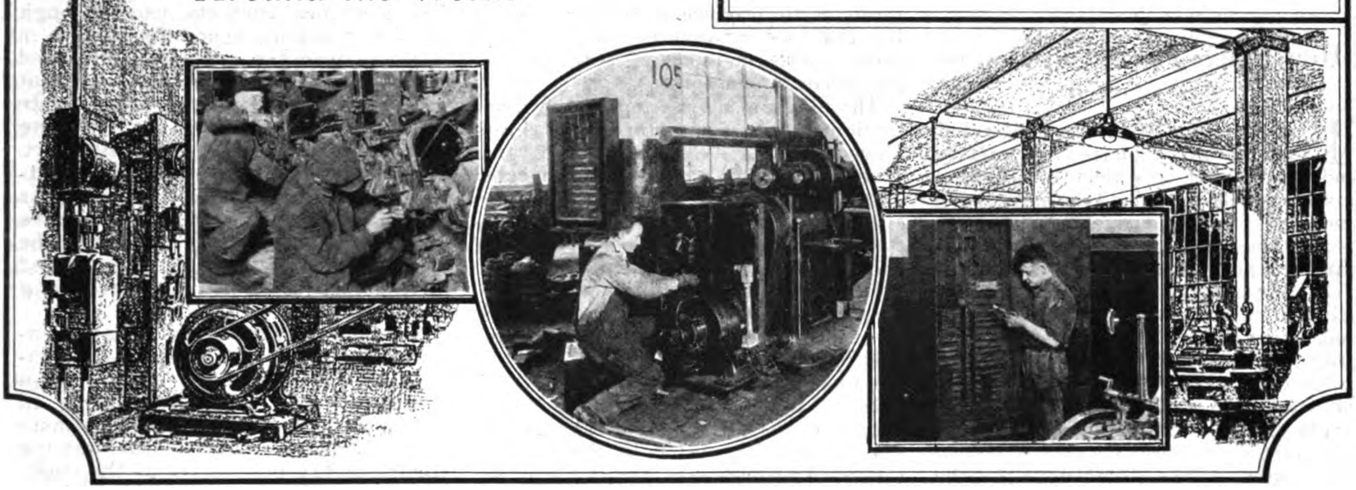
DONALD A. HAMPSON.

Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.

Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Operating 220-Volt Sand Cutter on 440-110-Volt System

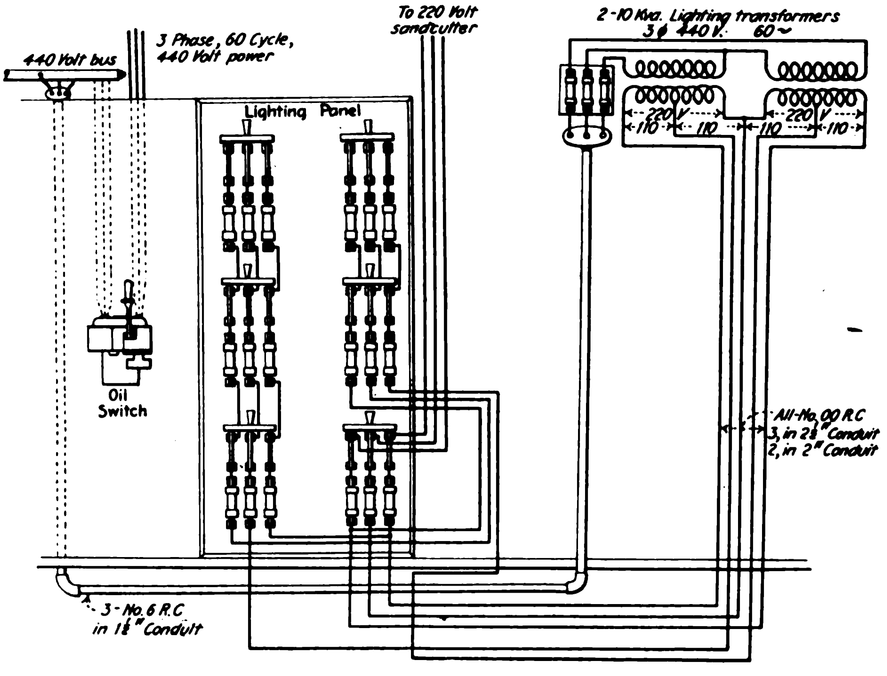
IN A PLANT where the 13,000-volt, 60-cycle, three-phase incoming power is stepped down to 440 volts through three 150-kw. transformers, the lighting system is supplied by two 10-kw. transformers which step the 440-volt power down to 110 volts. A problem which had to be met some time ago was the operation of a 220-volt sand cutter, the only motor of this voltage in the plant. The lighting transformers were so connected as to give 220 volts, three-phase, on three terminals of the secondary and 110 volts on all five terminals.

As a solution of the problem the three-phase, 440-volt power busbars at the switchboard were tapped off to the primary of the lighting transformers and protected by three fuses. The secondaries were connected in series and five equally-spaced leads were brought out. These are No. 00 rubber-covered conductors in conduit. The primary leads are three No. 6 rubber-covered conductors, also in conduit.

At the lighting switch panel, one 3-pole switch was disconnected from the busbars and to this switch the 220-volt, three-phase leads from the transformer were connected for operating the sand cutter, which is driven by a 7½-hp. motor.

The 110-volt leads are connected to the other five switches. As the sand cutter has a balanced load it causes no trouble except a slight flickering of the lamps at times, but as it is run only during the late night hours this does not matter. One-half of the total lighting load is carried by two switches and the other half by the remaining three switches in order to balance it as nearly as possible.

New Britain, Conn. H. S. RICH.



The secondaries of the 440-110-volt lighting transformers were connected in series to give 110-volts on all five terminals and 220 volts on three terminals, from which leads were run to the sand cutter through a three-pole switch on the lighting panel.

How to Restore Service Quickly After Fuse Blows

ON PAGE 605 of the December issue of INDUSTRIAL ENGINEER Donald L. Hoare described how he uses a double-throw switch with two fuse blocks for restoring power service when a fuse blows. This scheme is practicable, of course, but it should be noted that when fuses blow there is usually a reason and the trouble should be corrected. Offhand, one should not run to the double-throw switch immediately and throw it over on to the other set of fuses because this extra set will, in most cases, also blow. Such practice not only causes a waste of fuses but should be discouraged altogether, as liable to cause damage to electrical equipment. This extra "shot of juice" to a machine which is slightly damaged and which could probably have been easily repaired may make matters worse instead of better. Surely, the rule of "a stitch in time" applies to electrical equipment.

As another example of bad practice, I have seen electricians throw in the switch of a motor momentarily after it had failed. In this way they thought it was easier to locate the trouble, for the motor would spit fire at the fault. I have also seen other faults develop when a switch is thrown in this way several times. If the troubleman threw the switch in in this way only once, perhaps no serious results would follow, but usually he does not locate the exact spot of the trouble the first

time and so keeps on repeating the process until he does locate it. By that time, serious damage may have been done. I have always been against this practice and I should like to know what other readers of INDUSTRIAL ENGINEER think of it.

Oakland, Calif. S. H. SAMUELS.

How Single-Phase Fan Motors Are Started

THE function of the starting winding on single-phase fan motors, and the manner in which this function is discharged, is sometimes not clearly understood by repairmen. A description of the different types of fan-motor windings may, therefore, be of interest.

The three-phase induction motor is self-starting because of the revolving magnetic field resulting from the proper arrangement in the stator of coils which receive currents that are out of phase with each other. The single-phase motor is not inherently self-starting because it lacks a revolving magnetic field, due to its having a power supply from one phase only. Practically all alternating-current fan motors are of the induction type and are operated from a single-phase supply. To make these fan motors self-starting, recourse is had to split-phase windings and combinations of reactance and resistance. The action of these is to produce a revolving field. In the accompanying diagram are shown three methods of starting single-phase fan motors.

The diagram at the top of the illustration shows a fan motor with a three-phase winding. The parts of this winding, (A), (B) and (C) are connected together at a common point. They are spaced one-third of the pole spacing between centers of the poles of each winding. The (A) winding is connected directly to one side of the power supply; the (B) winding is connected to the reactance or choke coil which is situated in the base of the fan; and the (C) winding is connected through a resistance to the same side of the power supply as the (B) winding. This resistance is usually placed in the base of the fan. In some cases, the (C) winding is wound with small wire and a large number of turns to increase its resistance, and thereby do away with the need of the external resistance. Due to the reactance in series with the (B) winding, the current through it lags behind the current in the (C) winding which has resistance in series with it. The combined currents pass through the (A) winding; hence the current in (C) will lead the current in (A) and the current in (A) will lead the current in (B). This gives an approximate three-phase condition with a revolving magnetic field and the motor will start.

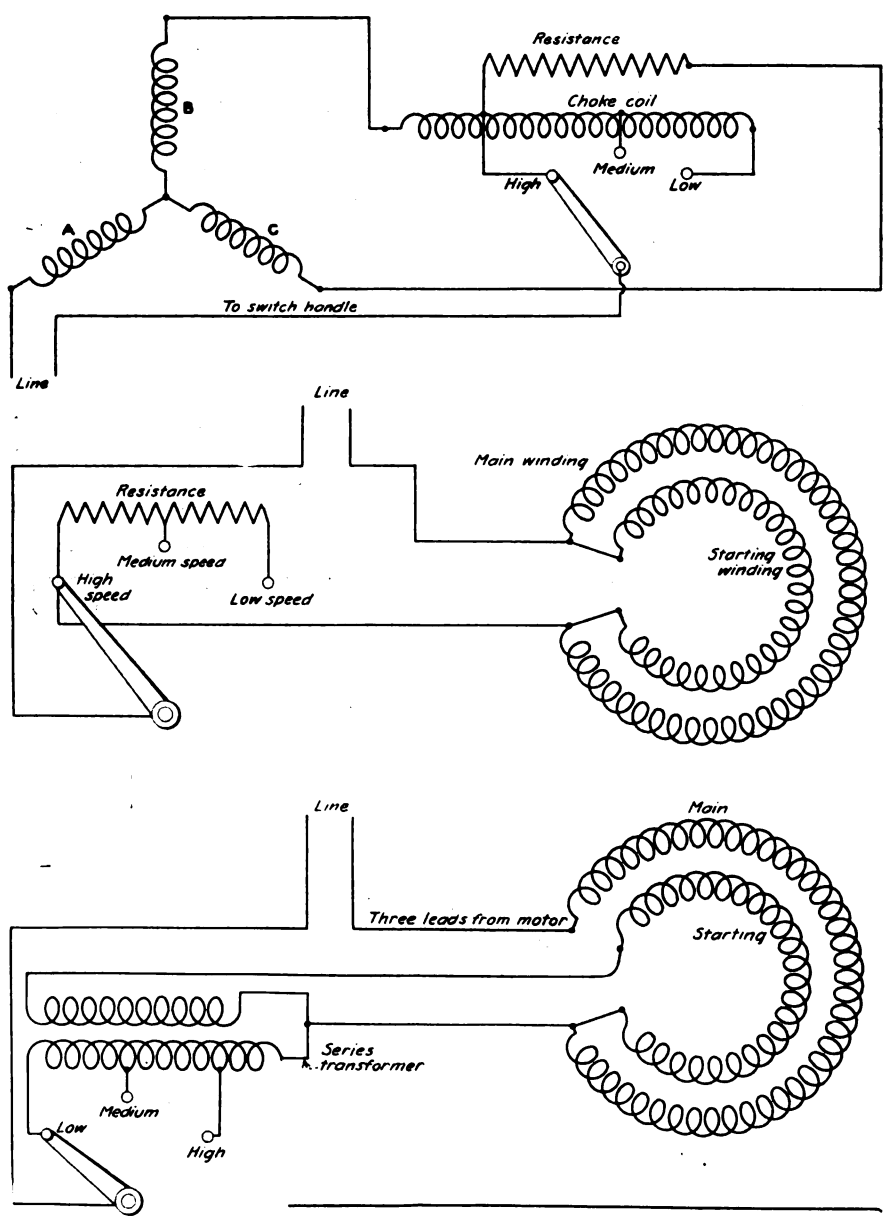
Speed regulation is obtained by cutting in more turns in the coil by means of the switch shown. Cutting in extra turns lowers the voltage applied to the winding, thus lowering the current and flux, increasing the slip and decreasing the speed.

The motor described above has essentially a three-phase winding—the motor shown in the middle diagram has a distributed-type winding, which is in two parts. One part is called the main winding and the other is the starting winding. The pole center of the starting winding is placed one-third of the pole spacing from the center of the pole of the main winding and overlaps the next pole of the main winding. The resistance of the starting winding is greater than that of the main winding; however, the main winding has the larger number of turns, hence, its reactance is greater. The two windings are connected in parallel; hence, when voltage is impressed on them, the current in the main winding will lag behind the current in the starting winding and the flux from the main winding will lag behind that of the starting winding. This produces an approximate two-phase condition with a revolving field and the motor will start.

To vary the speed, either resistance or a choke coil can be used in series with the winding; the added resistance or reactance decreases the voltage, which decreases the current and flux in the field, thus lowering the speed. Resistance in two steps giving three speeds is usually employed.

The latest type of fan winding is shown in the bottom diagram. There are two windings in this motor, a main winding and a starting winding, which are displaced 90 deg. In the base of the motor is a series transformer, the primary of which is connected in series with the main winding of the motor. The secondary winding of the series transformer is connected across the starting winding of the motor. Since the current induced in the secondary winding of the transformer lags behind the current in the primary, the current in the starting winding will lag behind that in the main winding, thus producing a two-phase effect, which starts the motor.

To increase the speed of the fan,



Three types of fan-motor windings in common use.

In the top diagram is shown a three-phase winding energized from a single-phase supply through a combination of resistance and reactance. In the middle diagram is a distributed type winding. The bottom diagram shows a somewhat similar winding with which a series transformer is used for starting.

turns are cut out of the primary winding of the transformer, thus decreasing the reactance in series with the main winding, and increasing the flux density.

The iron in the transformer is worked at a high density; hence the change in number of turns in the primary winding together with the change in primary current, has the combined effect of keeping the secondary voltage approximately constant. Consequently, a high starting torque at low speed is obtained.

The advantages of this type of winding are: greater speed range, reduction of power input with reduction of speed, high starting torque and a quiet running motor on single-phase, due to the distributed type of winding.

Detroit, Michigan. A. C. ROE.

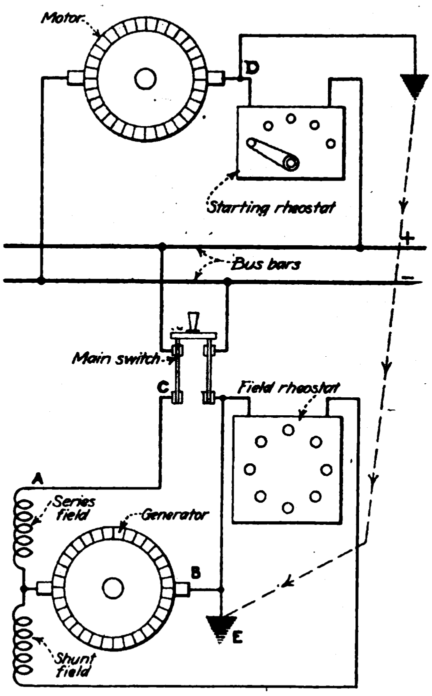
A Combination of Two Unusual Grounds Caused Shutdown of Generator

A PECULIAR failure occurred on a 110-volt, compound-wound, direct-current generator which supplies light and power for a small manufacturing plant. The failure occurred while the generator was running at full speed and while one of the largest motors in the plant was being started. The instant the arm of the motor-starting rheostat was pressed against the contact button, the pointer of the switchboard ammeter first indicated an excessive surge of current and then swung back to zero. It was apparent that the generator circuit had opened.

It was at first supposed that the difficulty was due to an opening in the series-field circuit. But when an incandescent lamp was connected between the series-field terminal and the negative brush terminal, at (A) and (B) in the diagram, the lamp glowed at full brilliancy, showing that the generator was delivering full voltage at this point.

It was then thought that the trouble might be due to a loose connection in the lead from the generator to the bus. When the connections were examined, it was found that the solder had melted out of the terminal which connects the positive lead of the generator to the main switch, shown at (B) in the diagram. This, of course, indicated overheating, which could occur only by the passage of an excessive current. It was evident that the heavy surge of current when the motor was being started had caused the cable to buckle and withdraw slightly from contact with the socket, thus opening the circuit from the generator.

The investigation was continued so as to locate the fault that caused the heavy flow of current. A ground was found on one of the motor leads, as indicated at (D) in the diagram. This ground was caused by the positive lead of the motor coming in contact with a water pipe.



A combination of grounds shut down the generator shown in this diagram.

One ground occurred on the positive side of the motor. The negative side of the generator came in contact with the insulated generator frame. The accompanying illustration of the generator shows how the insulated generator frame was grounded through the outflow pipe. These two grounds made a short circuit across the generator.

This discovery made the trouble appear more mysterious because the ground current must have a path back to the generator, and as the generator frame was mounted on insulation, the generator was considered as being insulated from the foundation.

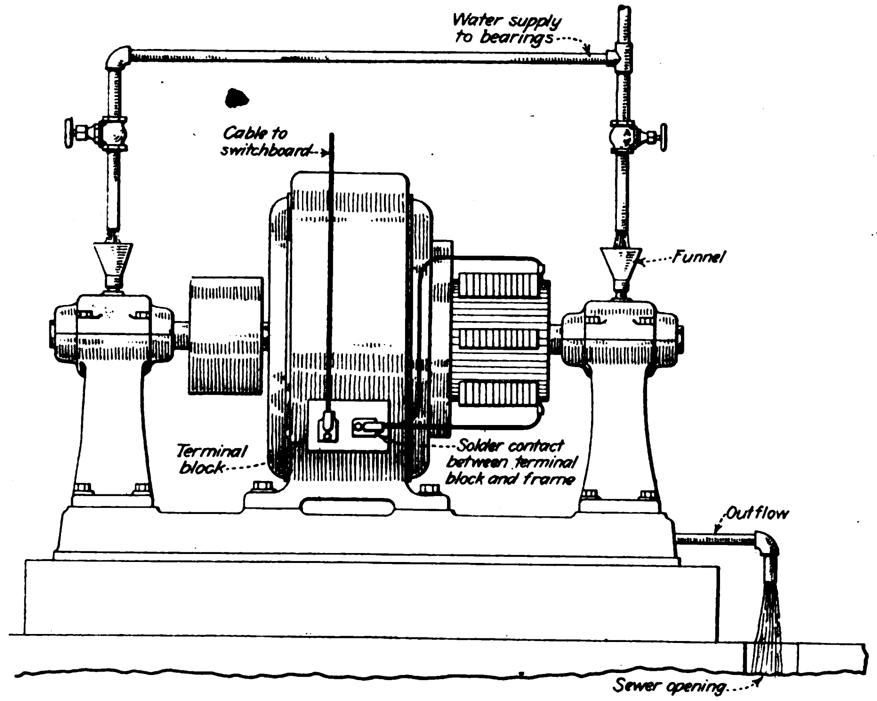
Further investigation disclosed that at the point where the lead from the negative brushes is connected to the terminal block, some repair work had been done during the preceding night, a part of which consisted in resoldering the connection. Owing to carelessness in doing the job, some of the solder had flowed down and made perfect metallic contact between the terminal block and the frame.

This accounted for a ground on the positive side of the line and for a connection to the generator frame from the negative side of the line. How the current passed from ground to the supposedly insulated generator frame was not seen until we remembered that the generator bearings were water-cooled as shown in the accompanying illustration of the generator mounting at the bottom of the page.

Although the generator bedplate had insulation beneath it, there was a path to ground through the overflow pipe shown at the bottom and at the right of the illustration, through the water to the sewer and to ground. This made a short circuit across the bus as indicated by the dotted line in the diagram. The short circuit traveled from the positive bus to the starting rheostat of the motor, to the positive lead of the motor, then to ground at (D), through the ground indicated by the dotted line to (E), and then to the negative lead of the generator, which is equivalent to the negative side of the line.

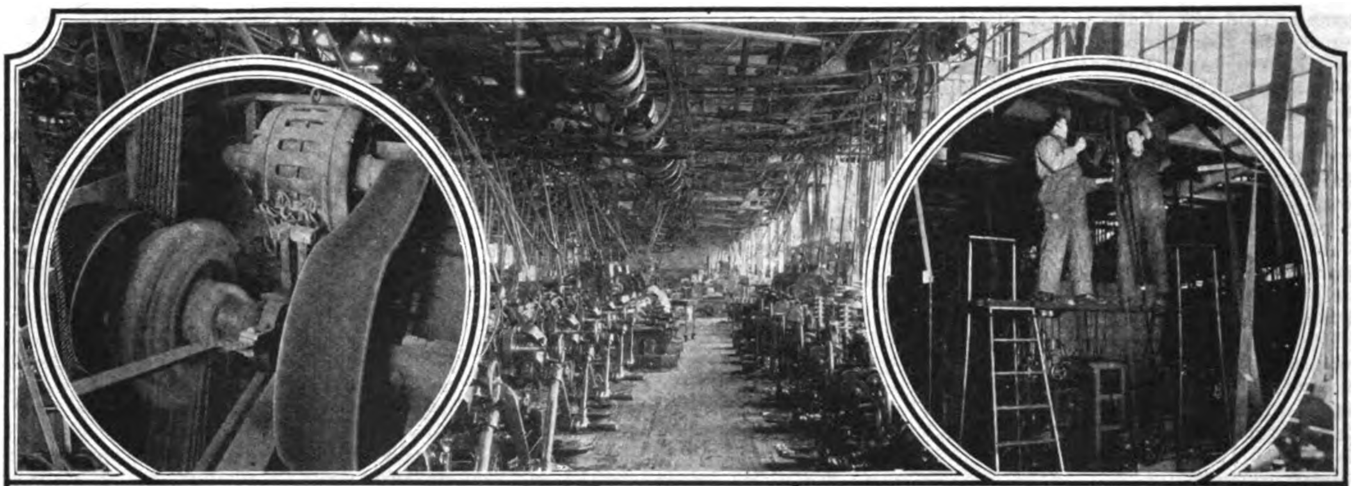
It is very probable that the resistance encountered by the ground current in passing through the water gap between the outflow of the bearing jacket and the sewer opening is all that prevented a disastrous burnout somewhere in the system which would have shut down the plant.

St. Louis, Mo. A. J. DIXON.



The bedplate of this generator is insulated from the cement foundation.

The generator was considered to be insulated from ground until it was discovered that current could flow from the bedplate through the outflow pipe, in the lower right-hand part of the illustration, through the water to the sewer and to ground.



Mechanical Maintenance of Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Simplifying the Installation of Ball Bearings on Main Lineshafts

THERE were two 120-ft. lines of 2¼-in. shafting in our machine shop, driven by a 20-hp. Westinghouse motor that was installed in 1904. The motor operated at 1100 r.p.m. which was stepped down to 140 r.p.m. on both lineshafts through belts to one jackshaft. The parallel lines of main shafts were connected (as was the motor drive) by 8 in. two-ply Schieren belting. When the installation was made, there were less than twenty-five machine tools in the shop; at the time of which I write, there were sixty-seven that were driven by this motor. Although the machines were not all run at once there were times when a large number of them were in operation. Among them were four planers, five screw machines up to 1 in., twenty No. 7 Becker millers, and other tools of related capacity.

The machinery was not all added at once and the increased power demand might have passed unnoticed, save for the necessity of changing 40 amp. fuses to 60 amp. and the frequent burning out of these. It was the electrical end of the situation that gave us the idea of a mechanical change.

We got the habit of reading the meter, first in checking up our bills and then as a measure of the amount of power we were consuming. We thus established our average hourly consumption in kilowatts over a long period. Then we ran the shafting idle for half an hour and an hour, and learned that our dead load was disproportionately high.

The main shafting was tried for level and alignment, but very little error was found. Then the countershafts were inspected to detect any unnecessary drag in them and some corrections were made. Machines that we were certain would not be used again for a month had their belts shifted off the mainshaft pulleys and the loop supported upon belt perches.

But these savings in power were small, as had been expected and we passed on to a ball-bearing installation as the real solution of the problem. Our main shaft lines ran in babbitted bearing hangers of Dodge make; the countershafts were the usual heterogeneous collection from machine tool builders and sundry makers of equipment.

We selected bearings that would go in our present hangers; these bearings are of the double-row type with one row of balls on each side of the hanger, slung in a casing held between pivoting setscrews. The bearings are clamped to the shaft by split sleeves.

For the countershafts, we put ball bearings only in those where the speed was excessive or the belt tension high. The installation of bearings of any type in a countershaft is of little interest, and this case was no exception.

But the installation of main shaft bearings involves a good deal of work because shafting must be uncoupled and lowered to the floor, pulleys stripped, and so forth. Frankly, we did not like the idea of doing this work and told the salesman that this was the one thing that stood between us and the dotted line. He said the cost to us would not be excessive, as they would send an expert from the factory to help and direct at no extra charge and all the expense we would have would be the wages of two men on one Sunday, for after looking over our lines he concluded that the installation was a very simple job. We believed all this, signed up, and in due time received the bearings and word that our man would be on hand the following Saturday to arrange things.

Our private opinion was that the job was bigger than it looked and we had arranged to have four of our men work Sunday, and that Saturday afternoon if wanted. We suggested the latter to the factory expert and he agreed, although he said it was not necessary and assured us that all would be running finely Monday morning.

On Monday morning the shop was in a sickening plight. Belts off everywhere, pulley halves scattered about the floor, nicely piled material knocked galley-west, dirt and litter over all. And what was worse, there were only eight out of twenty-eight bearings in their hangers. Our expert had skipped town, with word that he would be back next week.

It took us all the morning to get straightened out and ready to go to work in the afternoon. It might be added that the factory expert failed to show up the following week and through this failure we came in contact with the job of installing most of the bearings.

In attacking the job ourselves, we decided that it was wholly unnecessary to lower the shafts to the floor; also, that no pulleys need be removed, save those which interfered with the bearings in sliding them to position, and that no belts needed to be unhooked. As most of the belts had been installed and were running satisfactorily before we had a belt lacing machine, the task of unfastening these and connecting them up again was no small item—this item we intended to eliminate.

Our method was to provide a resting place for each length of shafting as it was taken out, right up in the air alongside its regular position. As the ball bearings were much larger where the case surrounded the balls than the space inside the hangers, it was necessary to get the shafts out of the hangers in order to slide the bearings in position, and then put the assembled job back, dropping the concave part of the casing over the pivotal set screw of the hanger. In this case the hangers were of the side outlet type, the gap in the hanger frame casting being closed by two links bolted on.

The accompanying illustration shows

the rests we made up. A side view of the rest in place on a post underneath the shafting is shown at (A); (B) is a sectional view from above. As will be seen they are extremely simple and cheap to make—and they proved equally efficient. The building construction included 8-in. by 8-in. oak posts set on 8-ft. centers and the overhead beams rested on these posts. The hangers were suspended from the beams, and the center line of the shaft was 15 in. out from the posts. The hangers had been erected with their opening side toward the posts—this was a little more convenient for us, but our scheme would have worked had the hangers been reversed.

The rests we made were U-shaped pieces of flat steel. They were sized at the open end to fit the posts, and the loop ends were made long enough and of such width that they extended several inches beyond the shaft and would admit the new bearings, which were somewhat longer than the plain ones which we were taking out. Three of these rests were made up and were amply sufficient for the job, as the shafting was in 20-ft. lengths.

In use, one of the bolts was taken out of the open end, so the rest could be put around the post. The bolt was then inserted, the rest shoved up against the under side of the shaft and both bolts securely tightened. These rests not only served to support the shafts as we took them out but they were a very close guide in re-aligning the shaft vertically when it came to adjusting the hanger screws to the new boxes.

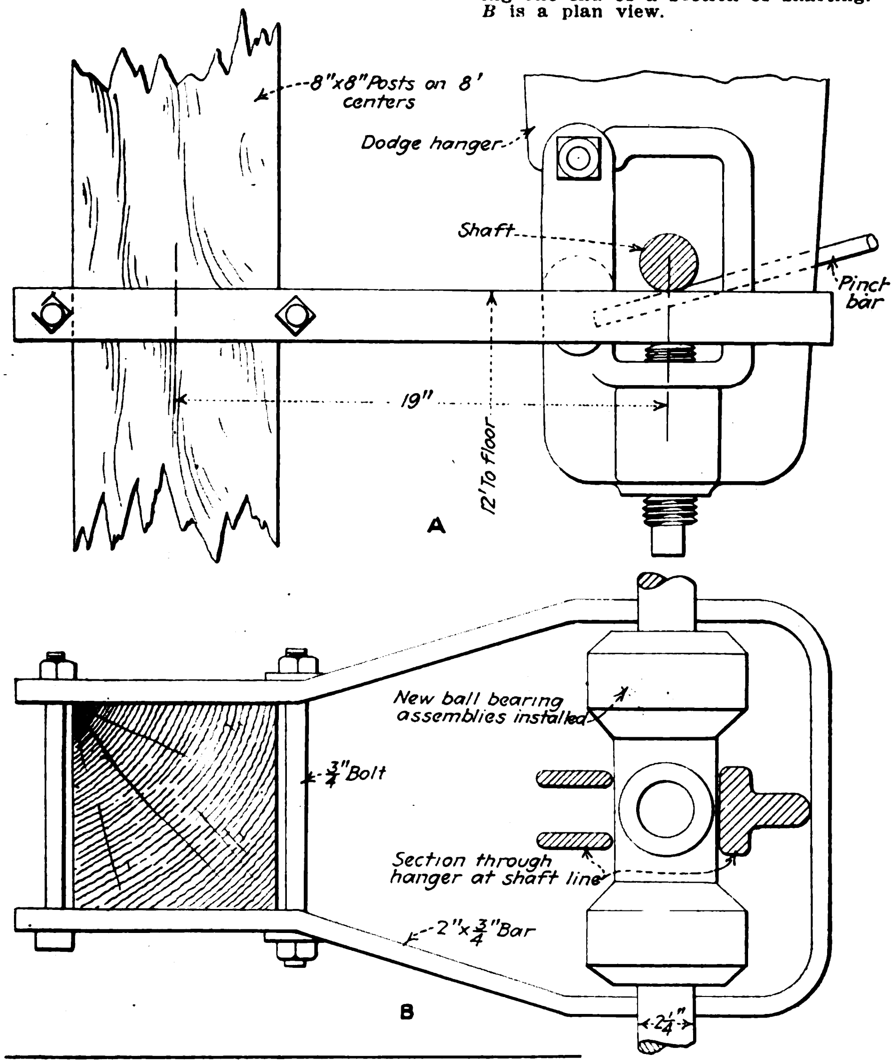
The loop end was also very useful in lifting the shaft out of the hanger pocket. Standing on horses or ladders, it is neither easy nor safe for men to juggle 200-lb. pieces of shafting, as the crew who had worked with the factory expert were quite willing to testify. With these rests, a small bar was used to pry the shaft up and out; in replacing the shafts, the same procedure was followed. The application of the bar is shown by dotted lines on the drawing.

With the shaft lengths laid out on the rests, it was a short job to get off the couplings and slide on the bearings. What pulleys had to be removed, were taken off first and these were not replaced until the lengths were coupled up again.

The free end of the shaft was aligned with the opposite end (the end which was coupled up) and then the center was brought up. Then the rests were taken off and moved to the next length. While some of the men were placing the rests in position, others were adjusting the top setscrews of the hangers and applying pulleys and belts to the length just assembled. In this way, the shafting was all ready for business by the time the section ahead was well under alteration.

With a simple rest like this it is not necessary to take shafting down when ball bearings are installed.

At *A* is shown a side view of the rest fastened to a post and supporting one end of a section of shafting. *B* is a plan view.



This method was so successful that the man-time per bearing installed was less than one-third of what it was for the few that were installed by the factory representative. The absurdity of lifting out and lowering heavy pieces of shafting with bulky pulleys on them cannot fail to be apparent—the labor involved is exceeded only by that required to raise the shafts back again. Yet countless instances of shafts lowered are recorded. Sometimes tackles and hoists are employed; after much work to secure the necessary headroom, these can often be used and they do save labor but the risk is increased, as witness the accidents resulting from shafts tipping and sliding out of their slings when, say, ten or twelve feet in the air.

Rests or supports are very easily made. They save their cost a dozen times over, on even a small job. Those made up for the job described above were retained in the stock room and have been of occasional use since. Also the same idea has been applied in other locations. In this case, the proximity of the posts suggested the design. In another location about the plant, a ball-bearing installation was made where the hangers were bolted to steel beams and here U-shaped pieces were forged up with a 10-in. flat section at the bottom and with clamping pieces at the top to fit the beam. This was used as a stirrup to support the shaft while making the change to ball bearings.

As to the results obtained from the use of ball bearings on our lineshafts, I have no record of the saving of power, in kilowatts, but I recall that there was a most noticeable difference in the bills and I do know that soon after they were installed we began to hook on machine after machine and it did not bother the already theoretically overloaded motor a bit.

Out of the ball bearings installed I have had one set go bad in about ten years. That was returned without local investigation and a service charge made for the repairs. That is the only expense we have been to in the matter of shaft bearings. They are oiled every six months.

For that matter, the Dodge babitted bearings never cost a cent for maintenance in an even longer period. They were oiled every four weeks.

I should say that the change we made is worth while for anyone. I put ball or roller bearings in machinery wherever I can, to cut the inevitable renewal expense, if for no other reason. It is interesting to note that these shafts run for thirty-eight seconds after the switch is opened—just time a shaft with plain bearings for comparison.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

An Easy Method of Moving Armatures Around the Shop

MANY small repair shops do not have an overhead traveling crane to move armatures around the shop. In the electric repair shop of our plant we have a small chain block in the center of the room, which we use to take apart the motors brought in for repairs. When the armature is lifted out by the chain block, the wooden wheels, shown in the illustration, are placed on the ends of the armature shaft. These keep the armature off the floor, thus keeping the winding from being rolled in the dirt and steel cuttings on the floor. Also, it affords a very convenient means of moving the armature around the shop. The armature can be very easily rolled to any desired spot, and it can be moved in very cramped quarters. By turning one wheel one way and the other wheel the other way, the armature can be turned end for end in a very small space.

The wheels are made from 2-in. planks and are about 4-in. larger in diameter than the armature on which they are to be placed. Two circular pieces are nailed together with the grain of one at right angles to the grain of the other. Then a hole, a little larger than the armature shaft, is drilled in the center of the wheel. Although a large wheel will fit most of the smaller armatures, it will be found more satisfactory to have several sizes of wheels, particularly if the range of armature sizes handled in the shop is very great. O. C. CALLOW.

Chief Electrician,
Trumbull Cliffs Furnace Company,
Warren, Ohio.

Wooden wheels placed on the end of the motor shaft afford a convenient means of moving an armature around the shop when no overhead crane service is available.

Two Simple Methods of Counting Coil Turns During Winding

IT IS usually necessary to know the number of turns being wound in a coil. I will describe two methods which I have used successfully and the reader may pick the one most easily adapted to his conditions.

The simplest means of counting turns is by using the ordinary revolution counter. For this purpose a tight-fitting wooden plug is driven into the outer end of the hollow spindle of the lathe used for winding. A small hole is made in the center of the plug and the "business end" of the revolution counter is fitted snugly in the hole so that the revolution counter is supported by this end in the axis of the lathe spindle. If the gears are well lubricated with sewing machine oil, it will be found that the weight of the counting mechanism is quite sufficient to cause the revolution counter to hang vertically, even at high lathe speeds. Now if the screw in the center of the dial of the counter is loosened so that there is just enough friction to cause the dial to revolve without slipping, the dial may be easily reset with the finger after a coil is wound. This will make it unnecessary to run the lathe to reset the dial to zero.

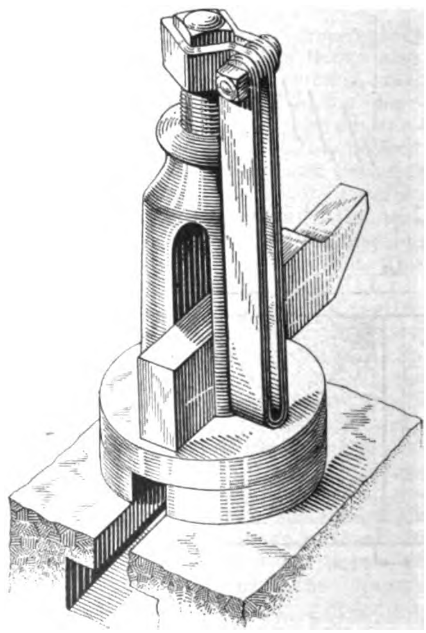
The second method of counting coil turns is by the use of the recording counter of an ordinary electric meter. A plug of wood is fitted into the hollow spindle in the manner described above, but instead of drilling a hole a staple is driven into the outside end of the plug. The unit hand of the recording counter is removed and a small loop of No. 18 copper wire is soldered to the stem. The recorder is mounted at right angles to the lathe spindle, with the shaft of the recorder parallel to the spindle axis and as close to the spindle as it can conveniently be placed. The recorder may be fastened to the wall, to a bracket from the wall, or to a bracket from the back of the lathe. A No. 12 wire is connected at one end to the staple on the spindle plug by means of a small loop. The other end is connected to the loop on the first stem of the recorder. This arrangement makes a drive with two universal couplings, hence it is not necessary that the apparatus be exactly in line.

Readings may be taken in the usual manner, by subtracting the original reading from that obtained after the coil is wound, although it is best to determine the final reading beforehand and when the hands come to this reading you will know that the coil is completely wound. S. H. SAMUELS.

Oakland, Calif.

Handy Tool-Post Wrench Which Stays On the Post

THE lathe tool post is a source of delay when it comes to shifting the tool position between cuts. Time is consumed in stooping to pick up the wrench, placing it on the tool post and removing it before starting the cut. This time can be saved through the adoption of a special wrench which was devised by one mechanic. In this wrench, which is illustrated here, the handle is made to swivel and hangs



This tool-post wrench will save time when shifting the position of the tool between cuts.

along the post stub when not being used to turn the screw.

The wrench is made from two steel strips, one of which is bent to the shape of the screw head and the other to a single bend forming the handle. These parts are fastened together with a bolt, the end of which is riveted over to prevent loosening. The wrench occupies but small space, is always at hand and through its use no time is lost shifting the tool position.

Washington, D. C. G. A. LUEBS.

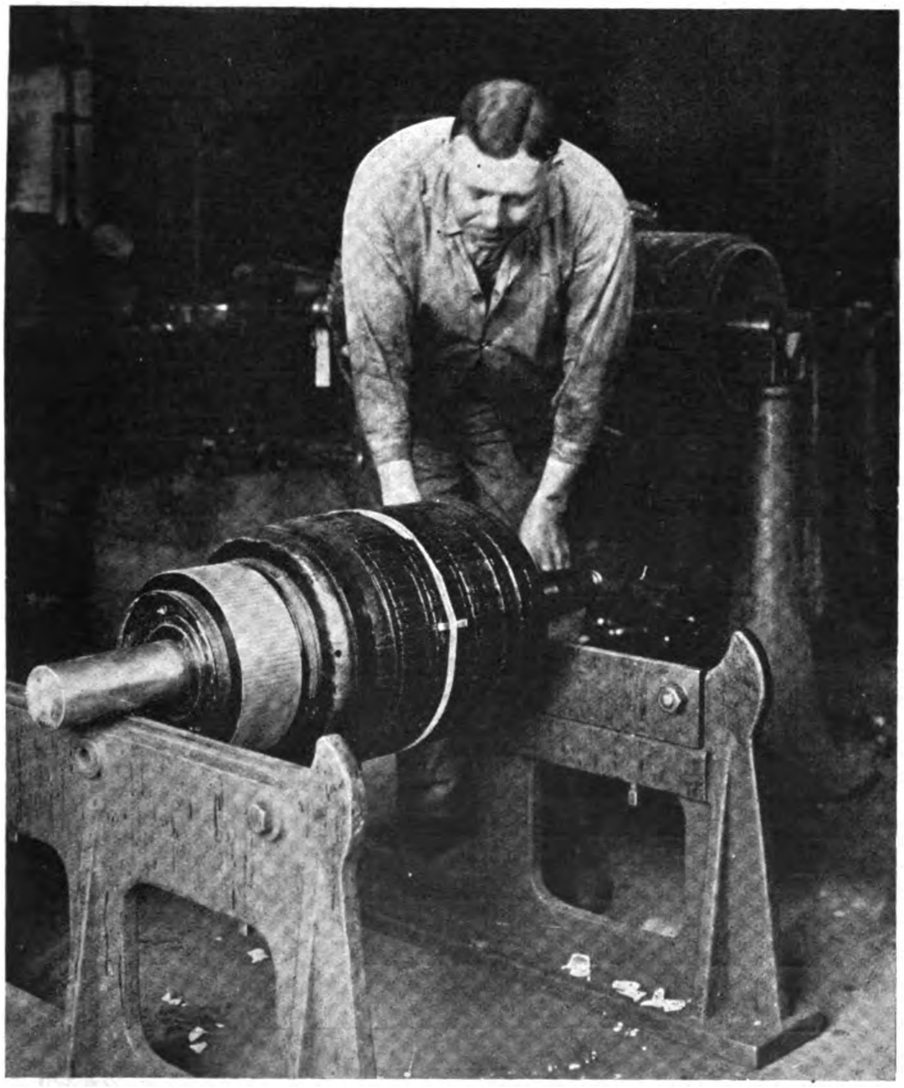
Method of Balancing Armature by Use of Rails

FOR the repair shop the most practical method of balancing an armature is by means of two level straight-edges or rails, as shown in the illustration. After being repaired the armature is placed with its shaft resting on the rails and is tried in several positions by rotating it until different sides are on top. If it stands still and does not tend to roll in any position, it may be considered to be balanced. If it tends to roll, the unbalance is counteracted by fastening a weight temporarily on the outside of the armature. In the illustration, this weight is a piece of ribbon solder and is held on the armature by a piece of tape. This weight must be adjusted both as regards size and position until the armature will remain at rest in any position. The location of the weight is then marked. After this, a permanent weight of the same mass as the one used for trial is permanently fastened on. In some armatures there are holes drilled for holding such balancing weights. A piece of solder of the proper weight may be placed in such a hole. In other cases, a small hole may be drilled and tapped in the spider and a weight fastened by means of a small bolt.

This method of balancing may not give satisfactory results with machines running over 1,800 r.p.m., or with very large machines running at even lower speed. In such cases, the machine should be balanced while running. A balancing machine gives the best results, of course, but this is seldom available in the ordinary repair shop.

Balancing may also be done by operating the machine without load at normal speed and marking the shaft with a piece of chalk or a pencil. This should be held at both ends of the shaft just close enough to touch on the high side if the machine is out of balance.

The shaft of the armature is placed on two level and parallel rails and weight added if necessary until the armature will remain in any position without rotating.



Then the machine is stopped and weights are added on the side opposite to the marks on the shaft. In making the trials the weights may have to be put first on one end of the armature and then on the other. Various positions should be tried until the vibration when running is eliminated. It may even be necessary to put a weight on one side of the shaft at the commutator end and on the other side at the other end. This is simply a cut-and-try method and a good deal of patience is required, but by repeated trials it is usually possible to get an armature or rotor well balanced.

New York, N. Y. H. E. H.

Three Interesting Experiences in Repairing Generators

HERE are some experiences which I have had in repair work and am passing on in the hope that they may help to save time and trouble for other readers of INDUSTRIAL ENGINEER who may find a similar difficulty.

One of my interesting experiences was in a packing house where a direct-current generator would not build up. The armature had been taken out and repaired and when it was put back into service the machine would not operate. Investigation showed that the engineer had put on a new set of brushes and had sanded them to fit the commutator perfectly. The brush holders, however, were of a type in which the brushes are fastened solidly in the holder with screws. The holders had worn enough to cause the brushes to strike the commutator only at the back corners, when the machine was started. After sanding the brushes in again, being careful to pull the sandpaper only in the direction the armature turned, the machine picked up its load without difficulty.

At another time some shunt field coils for a compound-wound generator were rewound and when the fields were put in the machine would not work. When rewinding, approximately the same weight of wire had been inserted in the new coils although but little attention had been paid to the number of turns. The generator had been connected as a short shunt—that is, the shunt lead had been connected to a compound lead for a line. When the new winding showed trouble, this short shunt was changed to a long shunt by putting the shunt lead onto the armature and compound leads. The machine then built up properly. The engineer said that before this the machine had required about three minutes to build up its voltage, whereas it now takes only about half a minute. Probably the machine had been over-compounded and the resistance of the compound cut out all the voltage that the armature would generate from the residual magnetism.

On another compound-wound generator that was connected short shunt, the machine ran extremely hot. When it was changed to a long shunt, the machine ran considerably cooler. I never could understand why this was, but this is what happened when we made the change.

Peoria, Ill. GEORGE RINGNESS.

Improvements in Bearing Service

(*Continued from page 270*)

except where the sleeves are split. (6) Their starting friction is practically the same as their running friction, which is of considerable advantage. (7) Their running friction is so low, regardless of load or supply of lubricant, that appreciable power savings result.

Here it is no more than fair to plain bearings to note that their running friction, provided all conditions are perfect, is also low. The fact is that conditions seldom approach perfection for any period of time and troubles arise as conditions vary.

In a vertical motor, the ball bearing stands almost alone. Here thrust and radial loads are present together, with a problem in lubrication. These conditions can be met easily by a properly designed ball bearing application with no greater difficulties than the horizontal motor presents.

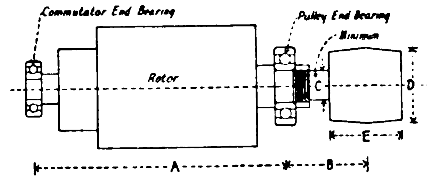
Further, regarding motor position, some people hang their motors upside down from the ceiling and some put them on the floor and belt up to ceiling-hung shafting. For the sleeve-type bearing, especially of the split construction dependent on oil grooves, rings, chains or wick packings, this requires some provision for moving the bearing and housings around to take care of load direction. A ball-bearing equipped motor simplifies this construction in that load direction to the ball bearing is not a factor of its satisfactory service. Plain bearings could be designed to take care of some of the above conditions. The disadvantages would be cost and lack of uniformity, each company designing their own.

Here the ball bearings are supreme in that their diameters and widths are established and their limits of accuracy standardized, each bearing of a given number being interchangeable with another of the same number even of different makes. This includes not only American but foreign-made bearings.

In conclusion the ball-bearing equipped electric motor is today serving where no other bearing has stood up. Almost universally where service conditions are unusually severe an investigation will show this is true, their selection being due entirely to the need of continuous service, other advantages being incidental.

Gurney Ball Bearing Co., Jamestown, N. Y.: This company has furnished the following table showing the sizes of bearings which they recommend for horizontal industrial electric motors.

The dimensions given in the table below refer to this diagram.



Ball Bearing Recommendations For Equipping Horizontal Industrial Electric Motors

Item No.	Motor Hp.	Speed R.P.M.	Torque Ft. Lbs.	Rotor Lbs.	Motor A	Motor B	Motor C	Pulley D	Pulley E	Bearing Loads Comm.	Bearing Loads Pul.	Bearing Sizes Comm.	Bearing Sizes Pulley
1	½	1800	1.46	12	6¾	2½	¾	2½	1½	20	57	203 Rad	204 Rad
2	½	1200	2.19	20	7½	2¾	⅞	3	2	32	80	203 Rad	205 Rad
3	1	1800	2.92							35	100	203 Rad	205 Rad
4	1	1200	4.38	30	8½	3	1 1/16	3½	2½	48	132	204 Rad	206 Rad
5	2	1800	5.84							50	160	204 Rad	206 Rad
6	1	900	5.84	40	9½	3⅜	1⅛	4	3	60	155	304 Rad	306 Rad
7	2	1200	8.76							77	222	304 Rad	306 Rad
8	3	1800	8.76							77	222	304 Rad	306 Rad
9	2	900	11.68	50	10¾	3¾	1⅜	4½	3½	95	265	305 Rad	307 Rad
10	3	1200	13.14							100	293	305 Rad	307 Rad
11	5	1800	14.60							110	323	305 Rad	307 Rad
12	3	900	17.52	60	11¾	4¼	1 9/16	5	4½	125	355	305 Rad	308 Rad
13	5	1200	21.9							145	433	305 Rad	308 Rad
14	7½	1800	21.9							145	433	305 Rad	308 Rad
15	5	900	29.2	80	12¾	4⅝	1¾	6	5	170	490	306 Rad	309 Rad
16	7½	1200	32.8							185	545	306 Rad	309 Rad
17	10	1800	29.2							170	490	306 Rad	309 Rad
18	7½	900	43.8	110	13¾	5	1⅞	7	5½	223	635	307 Rad	310 Rad
19	10	1200	43.8							223	635	307 Rad	310 Rad
20	15	1800	43.8							223	635	307 Rad	310 Rad
21	10	900	58.4	140	14¾	5½	2 1/16	8	6	273	755	308 Rad	311 Rad
22	15	1200	65.7							295	837	308 Rad	311 Rad
23	20	1800	58.4							273	755	308 Rad	411 Rad
24	15	900	87.5	170	15¾	6	2¼	9	7	357	997	309 Rad	312 Rad
25	20	1200	87.5							357	997	309 Rad	312 Rad
26	25	1800	73							317	850	309 Rad	412 Rad
27	20	900	117	210	17	6½	2	10	8	435	1207	310 Rad	313 Rad
28	25	1200	110							418	1145	310 Rad	313 Rad
29	30	1800	87.5							360	935	310 Rad	413 Rad
30	20	600	175	250	18½	7	2	10	9	610	1765	311 Rad	314 Rad
31	25	900	146							538	1400	311 Rad	314 Rad
32	30	1200	131							500	1368	311 Rad	314 Rad
33	40	1800	117							465	1235	311 Rad	414 Rad
34	25	600	219	300	20	7¾	2¾	12	10	667	1872	312 Rad	315 Rad
35	30	900	175							573	1535	312 Rad	315 Rad
36	40	1200	175							573	1535	312 Rad	415 Rad
37	50	1800	146							507	1300	312 Rad	415 Rad
38	30	600	263	350	22	8¼	2	12	11	775	2220	313 Rad	316 Rad
39	40	900	234							715	2000	313 Rad	416 Rad
40	50	1200	219							685	1890	313 Rad	416 Rad
41	60	1800	175							595	1557	314 Rad	316 DR
42	40	600	350	425	24	8	3	14	12	890	2540	314 Rad	317 Rad
43	50	900	292							792	2167	314 Rad	417 Rad
44	60	1200	263							740	1980	314 Rad	417 Rad
45	75	1800	219							665	1700	315 Rad	317 DR
46	50	600	438	500	26	9½	3	14	13	1085	3145	316 Rad	418 Rad
47	60	900	350							935	2585	316 Rad	418 Rad
48	75	1200	328							900	2443	316 Rad	318 DR
49	100	1800	292							835	2210	316 Rad	318 DR
50	60	600	525	600	28½	10	3	16	14	1170	3335	317 Rad	419 Rad
51	75	900	438							1040	2845	317 Rad	419 Rad
52	100	1200	438							1040	2845	317 Rad	319 DR
53	75	600	657	800	31	11¼	3	18	16	1410	3820	318 Rad	420 Rad
54	100	900	584							1310	3455	318 Rad	320 DR
55	125	1200	547							1263	3268	318 Rad	320 DR
56	100	600	875	1000	33½	12½	4	20	18	1740	4630	320 Rad	322 DR
57	125	900	730							1565	3970	320 Rad	322 DR
58	150	1200	657							1475	3640	320 Rad	322 DR
59	125	600	1093	1200	36	13¾	4	22	20	2055	5330	322 Rad	324 DR
60	150	900	875							1805	4430	322 Rad	324 DR

Brakes for Stopping Rotating Parts

(*Continued from page 274*)

several ways of fastening lining to the shoe. One method is to countersink the face of the shoe and drive a part of the woven lining into the countersunk space by means of copper rivets. This is the same method used in attaching automobile-brake linings. It is a very simple method and eliminates any chance of the linings loosening and at the same time permits the maximum amount of wear from the linings. Another method is shown in Fig. 7. Wooden blocks are surfaced so as to accurately fit the face of the brake wheel. The lining is glued to the surface of the blocks and is also held by countersunk brass screws. The ends of the lining lap over the ends of the wood block and are nailed thereto The block is then inserted under the lugs of the shoe.

In the disc-type brake there are two sets of friction plates; one is

known as the friction disc and rotates, the other is called the friction plate and is stationary. A cross-section of these is shown in II of Fig. 6. The rotating discs are made of steel and lined on both sides with a woven-asbestos lining. This lining is held in place by counter-sunk copper rivets. The stationary plates are made of iron and are machined on both sides.

Brake bands as used on band-type brakes are made of flexible sheet steel. There are cast or forged ears on each end of the band to provide means for anchoring the dead end and for attaching the live end to the actuating lever. The most common linings on band brakes are wood blocks, composition friction blocks, leather and woven-asbestos material. The last is probably the most used. It is fastened to the band in the same manner that has been described for shoes and discs.

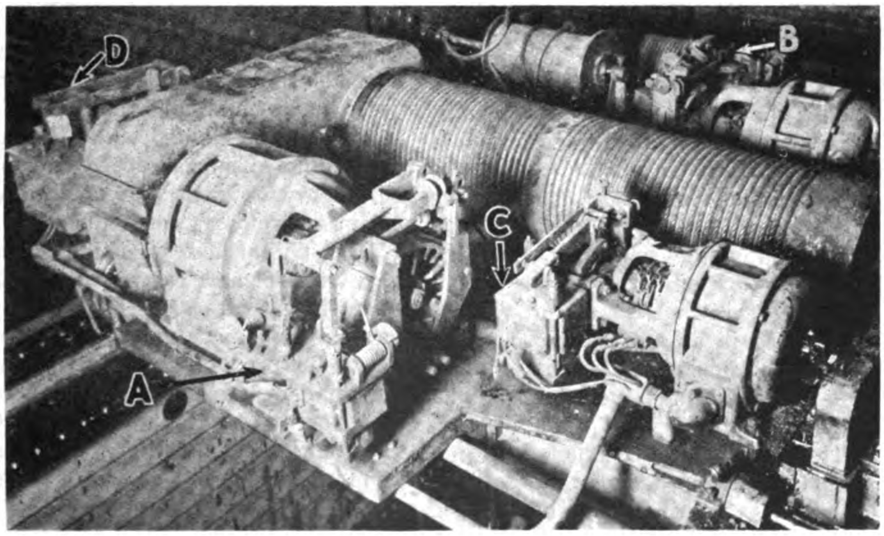
The second part of this article will appear in an early issue. In it will be discussed: brake linings; how brakes are rated; how to select brakes; data required when ordering; mounting, installation, adjusting, testing and maintenance of brakes, together with the troubles commonly experienced with them.

EDITOR'S NOTE: Special acknowledgment is made to the following companies for assistance in furnishing information, data and illustrations for this article: Allis-Chalmers Mfg. Co., Milwaukee, Wis.; E. C. Atkins & Co., Indianapolis, Ind.; Commercial Chemical Co., Boston, Mass.; Cutler-Hammer Mfg. Co., Milwaukee, Wis.; Electric Controller & Mfg. Co., Cleveland, Ohio; General Electric Co., Schenectady, N. Y.; Kelso Mfg. Co., Trenton, N. J.; Sundh Electric Co., Inc., Newark, N. J.; Thermoid Rubber Co., Trenton, N. J.; Tool Steel Gear and Pinion Co., Cincinnati, Ohio; Westinghouse Electric and Mfg. Co., East Pittsburgh, Pa.

In compiling this article information has been obtained from a chapter on electric brakes in a new book, "Principles of Electric Motors and Control," by Gordon Fox, published by the McGraw-Hill Book Co., and also from an excellent paper, "Auxiliary Electrical Equipment for Motor-Operated Cranes," presented before the A. I. E. E. in 1922 by H. W. Eastwood.

Fig. 10—At (A) and at (B) are multiple-solenoid brakes which give graduated braking.

These brakes are in use on wound-rotor, induction motors driving the main hoist and the auxiliary hoist of a 15-ton crane. At *C* is an alternating-current solenoid brake operating on the trolley motor of the crane. *D* is an emergency brake for the main hoist.



Improving Wiring Around Machinery

(*Continued from page 281*)

National Electrical Code specifies that there shall not be more than the equivalent of four quarter-bends between two consecutive outlets or fittings, the bends at the outlets not being counted.

Bending of conduit should be avoided wherever possible; standard elbows or condulet fittings are preferred. Although the material cost of doing the job in this way may be high, the increased labor cost and spoiled material resulting from complicated conduit bending may counterbalance this.

When using large wire, such as No. 00 in the 2-in. and larger sizes of conduit, use rear-cover condulets instead of those having covers on the side. With condulets having covers on the sides, it will be found almost impossible to force the wire through the outlets unless extra flexible wire is used, because of the small working space between the side outlet and the side of the condulet opposite the outlet.

Flexible metallic conduit is a great labor saver in tight quarters where several odd bends are required. It is also useful in places subjected to vibration that would loosen rigid conduit. It is the ideal connecting link between the motor condulet and the nearest solid support such as the ceiling, floor or wall where the rigid conduit begins.

Don't locate conduit too conspicuously, yet have it accessible. Conduit running across a floor should be buried below the surface or carried overhead and not run as conspicuously as shown in illustration *F*, page 276. Conduits running beside each other should be parallel and the bends in them should match. There is nothing more unsightly or more indicative of poor workmanship than four or five conduits running together, each with uneven and unequal bends. Conduits should be kept as close to the wall as possible, in the structural work, along the ceiling and the like, rather than run exposed with no protection.

In industrial works, all open work or knob-and-tube work should be avoided. Conduit work and underground cable work have been proved to be worth far more than the additional cost, in mills and factories.

Every so often some wireman will install a condulet having a cover, so that it is covered with cement, thus making it impossible to pull wires in or out without knocking a hole through the cement. It is a foolish thing to do, but it is done; so I mention it in passing. There are special condulets made for concealing in concrete, which have smooth bends similar to elbows and made without handholes and covers. Some wiremen use loom in exposed locations to protect wires that would otherwise be bare. That idea is all right, but the application of it is not. Flexible metallic conduit should be used in such places in the industrial plant.

The cost of wiring a given installation should be the last consideration in the layout of the job. Good wiring does not cost a great deal more than poor wiring and yields large returns in the form of decreased maintenance cost, less production delays, and fewer accidents.

EDITOR'S NOTE: Special acknowledgment is made to the Brunswick-Kroeschell Co., Chicago, Ill., for some of the pictures which show the excellent wiring in its factory, and to C. V. Putnam of the Reliance Electric & Engineering Co., Cleveland, Ohio, for suggestions and assistance in obtaining many of the illustrations used.

Best Ways to Use Insulating Varnish

(Continued from page 287)

loosened in service are tightened up and the coils are cemented in place.

Method of Securing Resistance to Acid

Resistance to acid fumes may be obtained by the same general process of treatment as has been outlined before. Thorough protection can only be expected when a smooth, glossy coat has been secured having no breaks in the continuity.

Method.—When the acid conditions are severe from two to four baked coats followed by heavy applications of suitable air-drying products will produce excellent results. The quick air-drying products, while quite unaffected by dilute hydrochloric or sulphuric acids, crack in service and allow the acid to get in under the film and actually lift the varnish from the surface. It is, therefore, better to use less brittle, slower-drying materials even at the expense of some slight increase in production cost.

Of the three major active acids hydrochloric and sulphuric are the easiest to protect against. Nitric acid on the other hand is much more powerful and will destroy any varnish so far made. When nitric acid fumes are present and all of the foregoing precautions have been taken in the treatment, it is best to go over the apparatus periodically and neutralize the acid by washing with a dilute alkali solution. The added maintenance expense is well worth while because when properly done this operation will prevent the necessity of frequent re-winding operations.

Providing Resistance Against Oil

This problem is similar to the other two insofar as treatment is concerned. The chief difference is in the choice of a suitable varnish. While one material may work well for both of the other problems it will not be at all adapted for extreme conditions such as are experienced in oil-cooled transformers. It is best in this case to consult the varnish manufacturer and select that material which has been designed for this purpose. Resistance to oil can be obtained only when the coils are completely and perfectly sealed and the varnish film baked until it is dry and hard. The soft, flexible materials become oil resisting only when they are baked for a sufficiently long period or at a sufficiently high temperature so that they lose, to some extent, their flexibility and become as hard as those products having shorter life.

Any product that will withstand transformer oil will withstand machine oil. Many materials that will not resist the former will be entirely suited for protection against the latter.

As a finishing coat over baked films, to secure additional protection, the alcohol-solvent varnishes are entirely suitable. They are very impervious to oil, but it must be borne in mind that they become insulators only when thoroughly dry and allowance must be made for this fact in the testing of the completed apparatus.

In selecting materials for these three classes of work remember that acid-resisting products are generally water resisting also, but they are not absolutely acidproof.

Protecting Against Metallic Dust

In most cases protection against metallic particles, carbon dust, etc., has been secured automatically when other conditions have been fulfilled. When conditions are extreme it is sometimes necessary to adopt extreme measures. A hard, smooth surface will prevent these particles from adhering and cutting their way through the insulation. This may usually be obtained by the use of a hard, air-drying varnish as an outer covering. When difficulty is still experienced it may be overcome by the use of a hard-setting cement which may be prepared in the shop.

General Remarks.—It must be remembered in reading the foregoing that we have been dealing with each problem separately and considering each condition as extreme. It is hoped that the reader will be able to adapt the procedure to his own individual needs. The problems seldom come singly. In motor treatment, for instance, we do not usually have to protect against moisture alone. Some oil will be splashed upon the windings. Furthermore, it is not always certain that the motor will not be placed in an atmosphere containing some acid fumes. Again, it may be used to drive a grinding or buffing machine where the metallic particles will be thrown upon the windings. Also the design of the armature may require that the varnish be the principal factor in holding the coils in the slots. A varnish for such service must, therefore, combine all of the characteristics which we have described. It must sacrifice protection in some directions for increased protection in others.

Another section of this article will take up conductor corrosion and other varnish problems.

Testing Insulation of Windings

(Continued from page 283)

Whether conditions of this sort can be maintained and whether such a test is desirable are questions difficult to answer. Not until operating conditions are standardized and operators' ideas on the subject correlated, can a satisfactory answer be obtained. The following tests have been used successfully under various operating conditions.

After the generators have been carefully examined and thoroughly cleaned they should be run on open circuit with sufficient excitation to raise the terminal voltage about 25 per cent above normal for five minutes. After the test, the voltage is reduced to normal and the several terminals grounded in succession. In making this test, arrangements must be made to break the field current instantly in case of failure.

This test is more searching than the application of an equivalent alternating-current potential from a testing transformer. The latter or so-called high-potential test is usually made between the windings and ground, whereas the generated voltage test described is in reality a test from turn to turn, from coil to coil, and from phase to phase.

A test frequently used on the windings of revolving fields is to subject them to two or three times normal exciting voltage, applied between one terminal and the shaft. The test should be applied while the field is running at normal speed and may be made with either direct or alternating current, as convenient.

High-potential tests using a testing transformer vary widely with different operators. Tests are required on armatures ranging from 10 to 60 per cent over normal and are applied for periods of time varying from one to thirty minutes. On revolving fields, voltages up to six times normal are applied for widely varying periods.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

The Borden Company, Warren, Ohio—A folder describes the new 106, 108 and 112 Beaver pipe cutters. These not only cut the pipe square without burrs, as do the other Beaver cutters, but are operated on a different principle which permits the operator to cut the larger sizes by hand quickly and easily.

Armstrong Brothers Tool Company, 317-357 North Francisco Avenue, Chicago, Ill.—Catalog B-23 covers the new line of pipe tools, dies, stocks, cutters and chain wrenches as well as a line of tool holders, ratchet drills, wrenches and other machine shop equipment.

Independent Pneumatic Tool Company, 600 West Jackson Boulevard, Chicago, Ill.—This company announces a new Thor reversible electric tapping machine, size UKR, for tapping small holes up to 3/16 in., and for retapping larger sizes up to 5/16 in. The reverse is strictly mechanical and so is claimed to eliminate the shock to the armature, which often occurs when a drill is reversed by electric current.

Crouse - Hinds Company, Syracuse, N. Y.—Bulletin 2054 describes condulets of the FA series. These condulets are provided with tumbler switches and covers and are designed for industrial purposes.

The Johns-Pratt Company, 160 Huyshope Avenue, Hartford, Conn.—A new folder entitled "Going Under Ground" describes some of the Noark underground boxes fitted with Noark fuses which it is claimed simplify installation, give a watertight construction for the protection of fuses in cable connections and safeguard against mechanical injury in underground transmission and distribution systems.

Janette Manufacturing Company, 556-558 West Monroe Street, Chicago, Ill.—A series of monthly bulletins entitled "Janette Talks" are issued and mailed to those interested as a medium of interest and a means of presenting the advantages of Janette special motors.

Industrial Controller Company, Milwaukee, Wis.—A circular illustrates the construction and operation of the Class 8605 oil-immersed automatic compensator. Two special features claimed for this are the conduit section for easy wiring and the accessibility of all contacts and connections.

Acme Electric Heating Company, Boston, Mass.—Loose-leaf sheets describe the special electric industrial heating appliances such as embossing-press heaters, cast-iron glue pots, sealing-wax pots, pots for melting metal, pitch kettles, melting ladles, cartridge heaters, and special laboratory heating devices.

General Electric Company, Schenectady, N. Y.—Bulletin 67100-A describes the construction and gives the various applications of safety enclosed, removable, truck-type switchboards.

Winfield H. Smith, 10-16 Lock Street, Buffalo, N. Y.—Catalog 21 gives specifications and prices, with illustrations, of a line of pulleys, arbor presses, reducing gears and revolving display tables manufactured by this company. These are all made for light service, such as in sewing rooms, in model work and in special display work.

The Ohio Electric and Controller Company, Cleveland, Ohio—A folder describes the Ohio motor-generator set designed primarily for charging small batteries. The generator may, however, be wound for any direct-current voltage up to 250 and used for intermittent or continuous service, such as signal or clock service system, or other work requiring a direct-current voltage not otherwise available.

The Esterline-Angus Company, Indianapolis, Ind.—Bulletin 324 entitled "Graphics Pay in Small Plants Too," shows how graphic meters in one small plant found a $4,000 waste of power by a defective 3-hp. motor. Other items discussed are the use of graphic records to create morale and for correcting low power factor.

General Electric Company, Schenectady, N. Y.—Circular 657-1, Class 15, describes the type IK-108-Y1 and type IK-109-Y1 polyphase induction reverse power (power directional) relays which are recommended for protection against power feed back on lines operating under a condition of leading power factor. These relays are for operation on 25- to 60-cycle circuits where the power factor may vary from approximately zero (90 deg.) leading to 0.17 (80 deg.) lagging.

The American Floor Surfacing Machine Company, 518 South Sinclair Street, Toledo, Ohio—A large folder describes the applications which may be made of the American Universal Floor Surfacing Machines in the treatment of new or old floors.

John C. Dolph Company, Newark, N. J.—A folder describes the Dolph Chinalak black baking insulating varnish and tells how it may be used to the best advantage. A price list is also given of the various other insulating varnishes manufactured.

The Pelton Water Wheel Company, Nineteenth and Alabama Streets, San Francisco, Calif.—Bulletin 19 describes the Pelton water wheels (impulse turbines), their construction and some of the various applications.

Mutual Electric and Machine Company, Detroit, Mich.—Bulletin 25 describes the "Bulldog" super-safety switchboard, industrial type, model DF5 with dead front. Both front and rear views are shown of several different switchboard installations.

Bethlehem Steel Company, Bethlehem, Pa.—Catalog M describes the large unit-type of Bethlehem oil engines for marine and stationary service. In addition to a thorough description of the construction and operation, space is devoted to the advantages claimed, rating and the result of an endurance run.

Crouse-Hinds Company, Syracuse, N.Y.—A large folder describes the FS series of condulets which are made in two-, three- and four-gang parallel and two-gang tandem for switch and plug receptacle outlets in vapor-proof and non-vapor proof types.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—An 8-page circular, C-1694, entitled "Supervisory Control" gives the general principles of operation and construction of both audible and visual systems of supervisory control for automatic substations.

Diehl Manufacturing Company, Elizabeth, N. J.—Circular 1012 D125 contains a brief description of the various types of motors made by this company together with a condensed price list of the most frequently called for standard apparatus. It also includes various types of exhaust fans as well as desk, bracket, ceiling and belted fans.

Bailey Meter Company, 2015 East Forty-sixth Street, Cleveland, Ohio—Bulletin 200 shows the application of the Bailey tachometers to indicate and record the speed of turbines, stokers, paper machines, fans, centrifugal pumps and other equipment.

Foote Brothers Gear and Machine Company, 213-223 North Curtis Street, Chicago, Ill.—A folder entitled "Reducing Motor Speeds—A Better Method" shows several applications of the Foote IXL spur-gear transformers which may be used to give a reduction of from two-to-one to five hundred-to-one or more, and IXL worm-gear transformers for heavy service.

Foamite-Childs Corporation, Turner Street, Utica, N. Y.—Bulletin entitled "Industrial Fire Chief," published in magazine form, shows many of the industrial applications of Foamite as a fire extinguisher.

The American Time-Switch Company, Commercial Building, Cleveland, Ohio—Folder B gives a description of the operation, construction and types of American time-switch clocks as well as some of the various uses to which they may be applied. These will turn current on or off automatically at any pre-determined time and are used for controlling lights, signs, alarm systems, storage battery charging or the operation of isolated motors.

The Hertner Electric Company, West One Hundred and Twelfth Street, Cleveland, Ohio.—Bulletins 5561-62-63-64-65-66 describe the individual motor-generator sets and automatic panels for constant-current charging of individual and multiple Edison

batteries and taper charging of individual and multiple lead batteries. In addition to numerous other charging data, another special feature is tables giving the approximate hours required to recharge lead batteries.

Liteweld Company, 2400 Woodland Avenue, Cleveland, Ohio—A circular describes the Liteweld track bonder and welder which is mounted on a light frame of steel tubing and angle iron and supported on pneumatic-tired, 30-in. wheels so as to give portability. While this device is made primarily for track work, it has many other applications where portability is desired.

B. E. Coil Former and Tool Company, 122-130 Centre Street, N. Y.—A circular illustrates and describes the Townsend combination coil winder and spreader which it is claimed does away with the use of home-made wooden forms and pulling blocks. Immediately after the coil is wound it is pulled on the same machine and is ready for the taper.

The Hayward Company, 50 Church Street, New York, N. Y.—Pamphlet 620 describes the Hayward automatic take-up cable reels and cable couplers for use in connection with motor buckets or electric magnets when used on a locomotive or traveling crane to prevent accidents, wear or short circuits due to the sagging of the conductor cables. The reel operates on the principle of an ordinary shade roller with the rotating power supplied by a set of compounded springs which are enclosed within the drum.

American Di-Electrics, Ltd., 466 East Seventh Street, Brooklyn, New York. —Price list 123 lists, with the price, the various electrical insulating varnishes and compounds made by this company and gives instructions for their use.

The Arrow Electric Company, Hartford, Conn.—A circular entitled "It Won't Come Out," shows the various types of Arro-Grip sockets for industrial plants, mills and shops. The special feature of this socket is that it is constructed to take the strain off the binding posts and prevent shorts from fraying wires. It also provides a strong wiring device for holding up reflectors or heavy fixtures.

The Martindale Electric Company, 11709 Detroit Avenue, Cleveland, Ohio—A circular lists the various types and sizes of Imperial commutator stones and commutator-grinding tools.

Burke Electric Company, Erie, Pa.—In bulletin No. 127 details are given of variable voltage types of arc welding outfits of portable and stationary design. A 400-amp. equipment is made that two operators can use on the same job or on different classes of work without interference, or one operator may use the full capacity of the set. The Burke Electric Company has recently opened a branch service and sales office in Chicago with M. E. Standish as manager at 310 South Michigan Blvd., Chicago, Ill. This company makes a full line of direct- and alternating-current motors and generators for power stations and all classes of industrial service.

Practical Books

For Your Personal Library

Every man who aspires to larger responsibilities should build up a professional library. Copies of these books may be obtained from the publishers mentioned.

Practical Electro-Plating—By W. L. D. Bedell. Fifth edition, Distributed by The Hanson and Van Winkle Company, Newark, N. J. 407 pages, illustrated. Price $3.00.

It has been the author's aim in compiling this work to instruct the operator, in a practical manner, in the art of electro-plating, polishing, buffing, and metal finishing. This book illustrates and describes the necessary equipment and supplies, states what they are used for, and how to use them. The general shop arrangement is first described; then, beginning with the installation of the generator, the complete electrical equipment is considered in the order in which it should be set up and connected. Other necessary equipment and information is given in regular order.

In the electro-deposition of the standard commercial metals, formulas are given for making and operating various plating solutions, dips, and pickles, as well as the manner in which they should be maintained and renewed.

* * * *

Cast-Iron Welding by the Oxy-Acetylene Process—Compiled and published by the Linde Air Products Company, 30 East Forty-second Street, New York, N. Y., 115 pages, illustrated.

The purpose of this booklet is to give the proper application of the accepted practices in oxy-acetylene welding of cast iron toward the solution of various problems. Among the subjects treated are: Nature and properties of gray cast iron, application of welding to cast iron, equipment, preparation, preheating, welding, annealing, finishing, testing welds, estimating welding cost, and some typical cast-iron welding jobs. An appendix gives ten practical problems in cast-iron welding and shows how they may be solved. The book is well illustrated with both halftones and drawings throughout.

* * * *

Diesel Engines—By Lacey H. Morrison of the editorial staff of **Power.** Published by McGraw-Hill Book Company, 370 Seventh avenue, New York City, 598 pages, 385 illustrations. Price $5.00.

The increase in the cost of power in coal-burning power plants has caused many to give serious consideration to the Diesel engine. This book not only gives a complete and comprehensive statement of the use, construction, operation, maintenance and repair of Diesel engines, but also gives a wealth of data on its economic status in the public utility and industrial fields. A chapter is devoted to a detailed discussion of initial costs, labor costs, maintenance charges, fuel consumption and actual operating and production results. A short history of the development of the Diesel engine is given. The body of the book is devoted to a practical discussion of the various types of engines from the standpoint of frames, cylinders, pistons, connecting rods, crank shafts, bearings, valves, fuel pumps and governors. Chapters of particular value are those on: installation, in which step-by-step methods of erection are given; cooling systems, in which advanced methods of cooling are described together with means of reclaiming the exhaust heat; Diesel fuel oils; and one on indicating the Diesel engine, in which is given a thorough analysis of Diesel engine indicator diagrams. In this connection there is given not only a discussion of indicators particularly adapted to the Diesel engine, but also the manner of rigging the indicator, the errors to avoid, and the interpretation and study of the diagram. The book is written in a manner that will appeal to those having anything to do with the selection, purchase, management or operation of the Diesel engine.

* * * *

Supervision and Maintenance of Steam-Raising Plant—By Charles A. Suckan. Published by The Van Nostrand Company, 8 Warren Street, New York City, 326 pages, illustrated. Price $8.

In the preface of this book the author points out that a new type of engineer is coming into being; namely, the combustion engineer or engineer-chemist whose function it is to assist power plant owners, managers and engineers in the efficient operation of steam-raising plants under existing conditions. The book has been prepared as a handy work of references with all information presented in simple form and the discussions of the theoretical side of the subject reduced to a minimum. It is divided into two parts; the first deals with the supervision and actual working of a plant while the second takes up repairing and general overhauling.

In the first part the following subjects are dealt with: (1) details of the boiler plant; (2) combustion of fuel; (3) method of firing; (4) regulation of draught; (5) superheaters; (6) economizers; (7) pumps, injectors, and meters; (8) handling of fuel; (9) handling of ashes; (10) feed water plant; (11) pipe system; (12) routine of boiler-house staff; (13) office staff; (14) testing.

The second part, devoted to maintenance, discusses the following subjects: (15) internal inspection; (16) external inspection; (17) boiler brickwork; (18) "laying up"; (19) auxiliary appliances; (20) auxiliary plant brickwork; (21) workshop organization; (22) feed-water plant; (23) pipe lines; (24) structural repairs; (25) conclusion.

There are 250 illustrations of equipment and installation details which make it easy to understand the practical points which the text describes.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded 1882 as the Electrical Review

JULY, 1924

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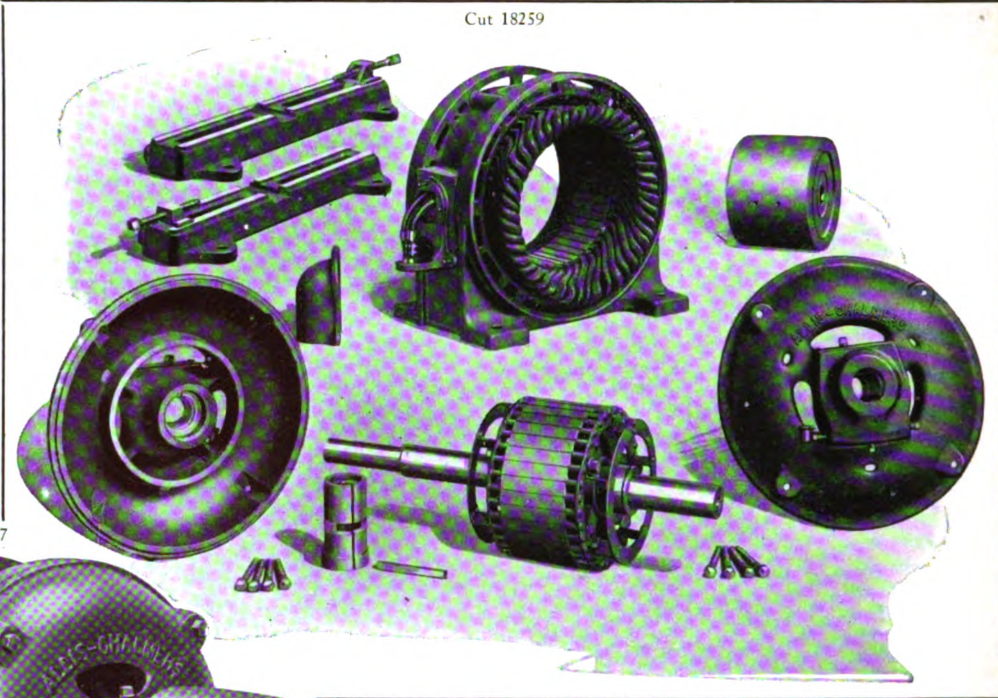

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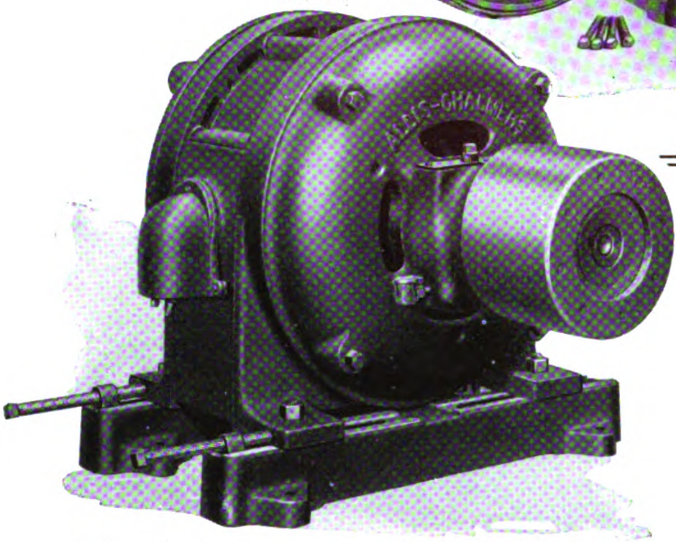

Type "AR" Squirrel Cage Belted Motor.

Here are the parts:

Above is shown a new Allis-Chalmers type "AR" motor disassembled. Note its simplicity. What you see above is the complete motor. Its lack of complexity is one of the features of the type "AR" which gives it its high service value.

Allis-Chalmers type "AR" motors are built of steel practically throughout. The stator end frames and feet are integral and made from electric steel castings. The rigidity resulting from this eliminates the possibility of broken end frames and feet.

By careful well balanced design, the use of selected materials and by good workmanship and construction, high efficiency over a large range of the working load with correspondingly high power factor have been attained in these new motors.

Built in capacities from ¾ to 200 H. P.

ALLIS-CHALMERS MANUFACTURING CO.
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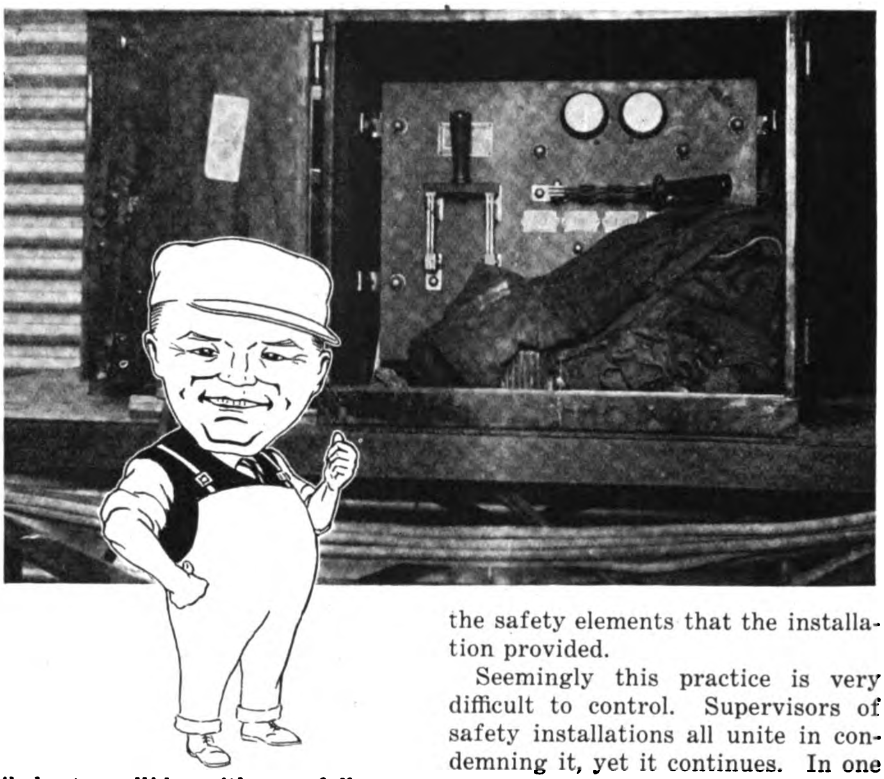
INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of
Electrical and Associated Mechanical Systems in Mills and Factories

Volume 82 Chicago, July, 1924 *Number 7*

When Switch Cabinets Are Used as Lockers

A Danger Trap Is Set That in Time Will Catch the Offender or Some Maintenance Inspector



HERE'S a photograph I took on a recent inspection trip that shows a practice more widespread than is commonly supposed. When enclosures like this one are used as a catch-all for lunch baskets, clothing, tools, oily gloves and the like, a danger trap is set that sometime or other will catch the offender or the inspector who must maintain the equipment. I hate to preach about a practice like this in a critical way, but I feel that the importance of the danger justifies placing the blame squarely up to the guilty individual. If he does not know the serious results that may occur he can be excused once, but if he does know the danger trap he sets and continues the practice a discharge without discussion is the proper penalty.

In the plant where this photograph was taken almost everything possible has been done to provide safety and protection for operators and workmen. Gears, belts and chains are enclosed with safety guards. There is no open wiring, with good use being made of rigid and flexible conduit. Safety stops are provided where necessary. Tools and materials in process have their proper places so that the workman is not likely to collide with, or fall over, them while at work.

Very liberal use has been made of safety switches, push-button control switches and of enclosures for distribution and control cabinets. The cabinet which is illustrated encloses the generator control panel of an arc welding set. This installation represents unusually good practice. The motor-generator and the stabilizer are mounted on a steel table which is about waist high, so as to make the apparatus convenient for inspection and maintenance. The starter near the motor is enclosed and controlled by a conveniently located push button. The stabilizer or reactance is totally enclosed with grillwork.

It is evident that the operating management has provided a safe installation for the workmen and for those who are called upon to maintain this equipment. The man who used this control cabinet as a locker, however, defeated in a serious way the safety elements that the installation provided.

Seemingly this practice is very difficult to control. Supervisors of safety installations all unite in condemning it, yet it continues. In one plant this evil has been effectively combated by placing padlocks on all enclosures and giving keys only to inspectors who are responsible for the operation or maintenance of the equipment enclosed. This is one definite way of locating an individual who either has a total disregard for the need of safety or carelessly ignores the safety practices that are now so commonly provided. Since safety work depends as largely upon the individual as upon the method, a careless individual is just as serious a hazard to his fellow workmen as the device which needs protection.

If any of our readers have found a way of stopping this practice of using safety enclosures for lockers we should be glad to know the way they have gone about it.

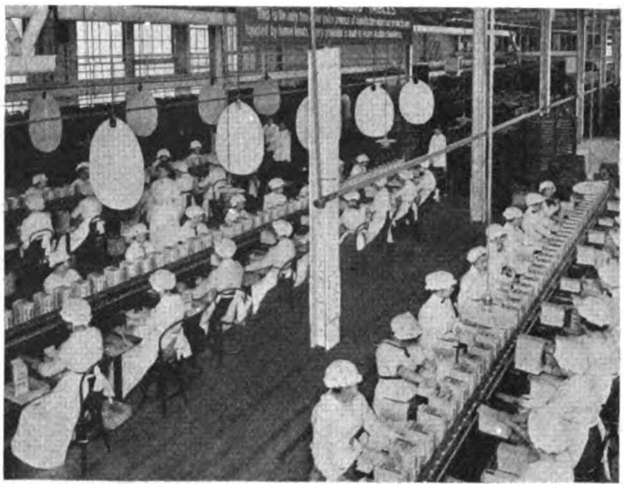
Practical Pete

A Glimpse Into the

Works of The Shredded Wheat Company

Where 6,000 bushels of wheat are daily put through a special cooking, shredding and baking process which transforms it into a delicious cereal food. An open-house policy to guests attracts over 100,000 visitors every year.

ONE of the big problems of all food-products plants is to maintain a high degree of cleanliness, both of equipment and surroundings. The factories of The Shredded Wheat Company are planned to help make this easy. For example, plenty of light is one of the best antidotes for poor housekeeping. Therefore, the walls of the building are constructed with large window areas which eliminate dark corners. Concrete floors add to the ease with which the force of janitors maintains good housekeeping.

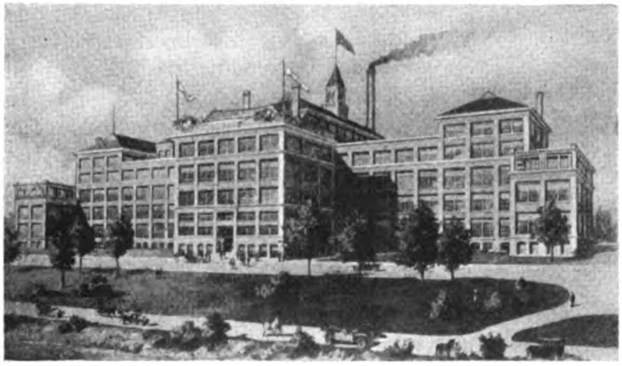


Three of the rows of packing tables each with a double file of girls.

Because of the fragile nature of the product, the biscuits must be inserted into the cartons by hand. The filled boxes are carried by conveyor to a sealing machine which closes both ends and seals them up so that the carton is practically moisture and air tight.

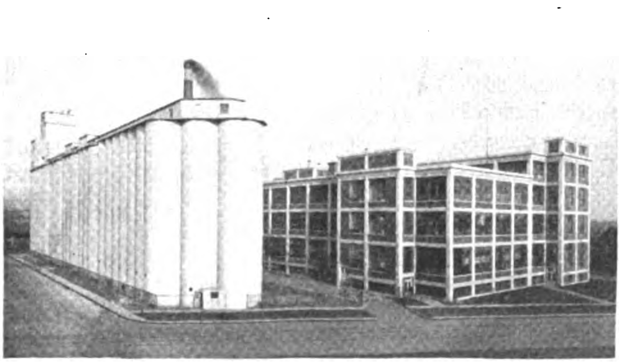
In addition, much attention is given to the personnel, for even with bright and cheerful surroundings, the actual keeping of the factory and product clean depends upon the care of the workers. Therefore, welfare work is carried on extensively. In addition to a visiting nurse, a dispensary in charge of a trained nurse, individual lockers, rest rooms and lunch rooms (which are free to the women workers), opportunity is given to the workers for bathing and otherwise encouraging cleanliness and neatness. A large auditorium, capable of seating 1,000 persons, is used from time to time for lectures and other entertainments as well as dances and parties.

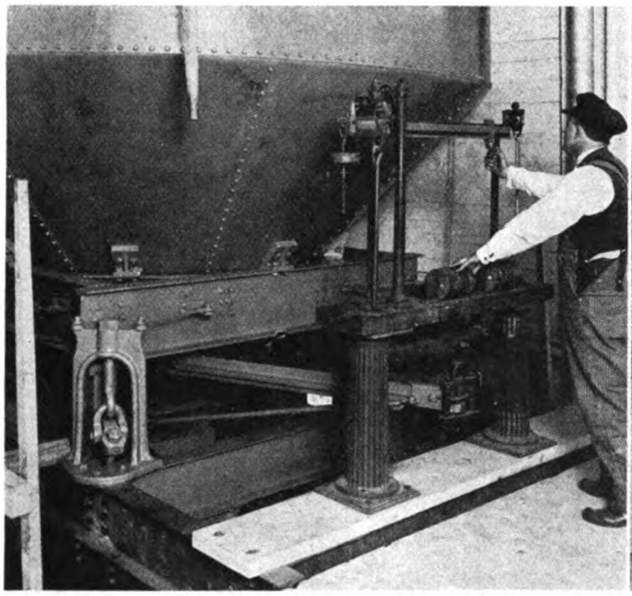
About thirty years ago Mr. Perky developed the idea of making from the whole of the wheat, a cereal which could be baked in a biscuit and would keep indefinitely. An attractive location on the banks of the Niagara River within a short distance of the American Falls was chosen for the factory which was erected in 1901. The main factory is five stories high, 463 ft. long by 66 ft. in depth with four side extensions and contains 276,586 square feet of floor space devoted to office and manufacturing purposes. Natural lighting is supplied by 884 windows with 30,000 lights of glass, which alone offer a big problem in the necessary replacements and in keeping them clean. Additional fac-

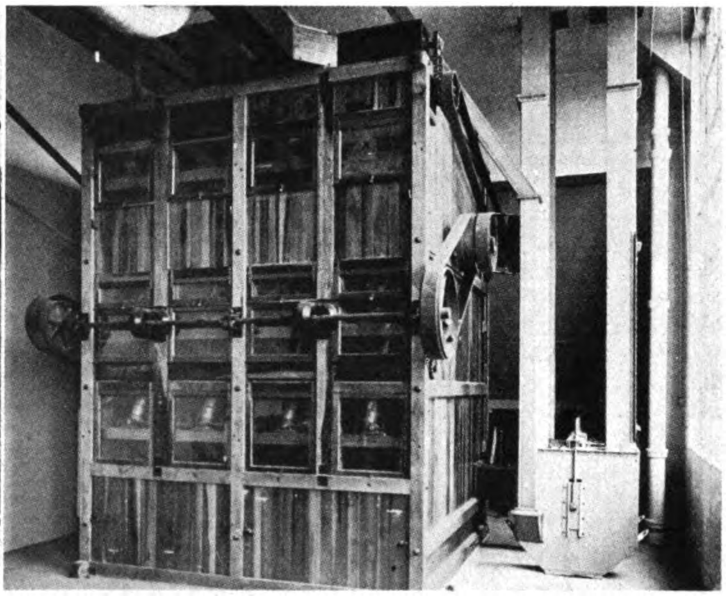


Here are three of the four plants of The Shredded Wheat Company.

The two plants shown at the left are at Niagara Falls, N. Y. The plant at the top is the main factory and is built within sight of the American Falls. The plant below at the left is built a few blocks away, with a large wheat storage tank having a capacity of 750,000 bushels. Elaborate dust collectors which have been made as the result of a number of years of experimental work are installed with this. Over 1,800 tons of dust and defective grain as well as weed seeds are removed from the wheat each year in the cleaning process. The plant below is located at Oakland, California.





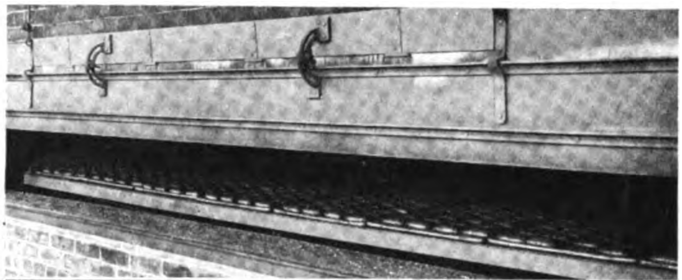


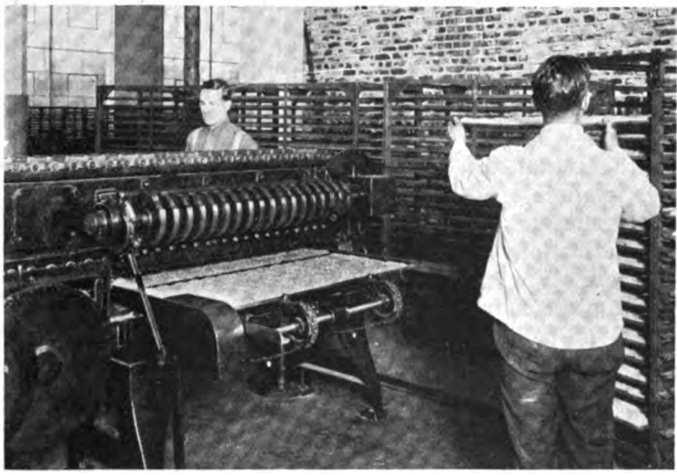
Weighing and cleaning the wheat.
All wheat is first weighed. The wheat is then passed through twenty-two cleaning machines which remove all the dust, dirt, weed seed, shrunken and imperfect grains and any foreign material which might damage the rolls. Altogether, 1,800 tons of this material are removed during the year.

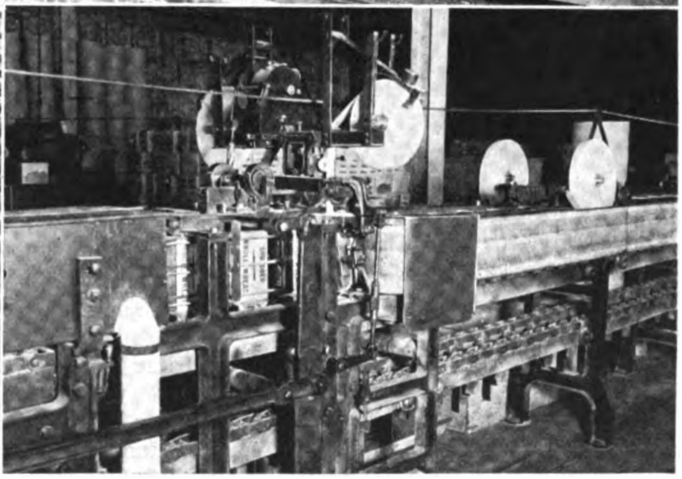
tories are located at Oakland, Calif., Niagara Falls, Canada, and a second factory at Niagara Falls, N. Y. All are quite similar in that they have large window area.

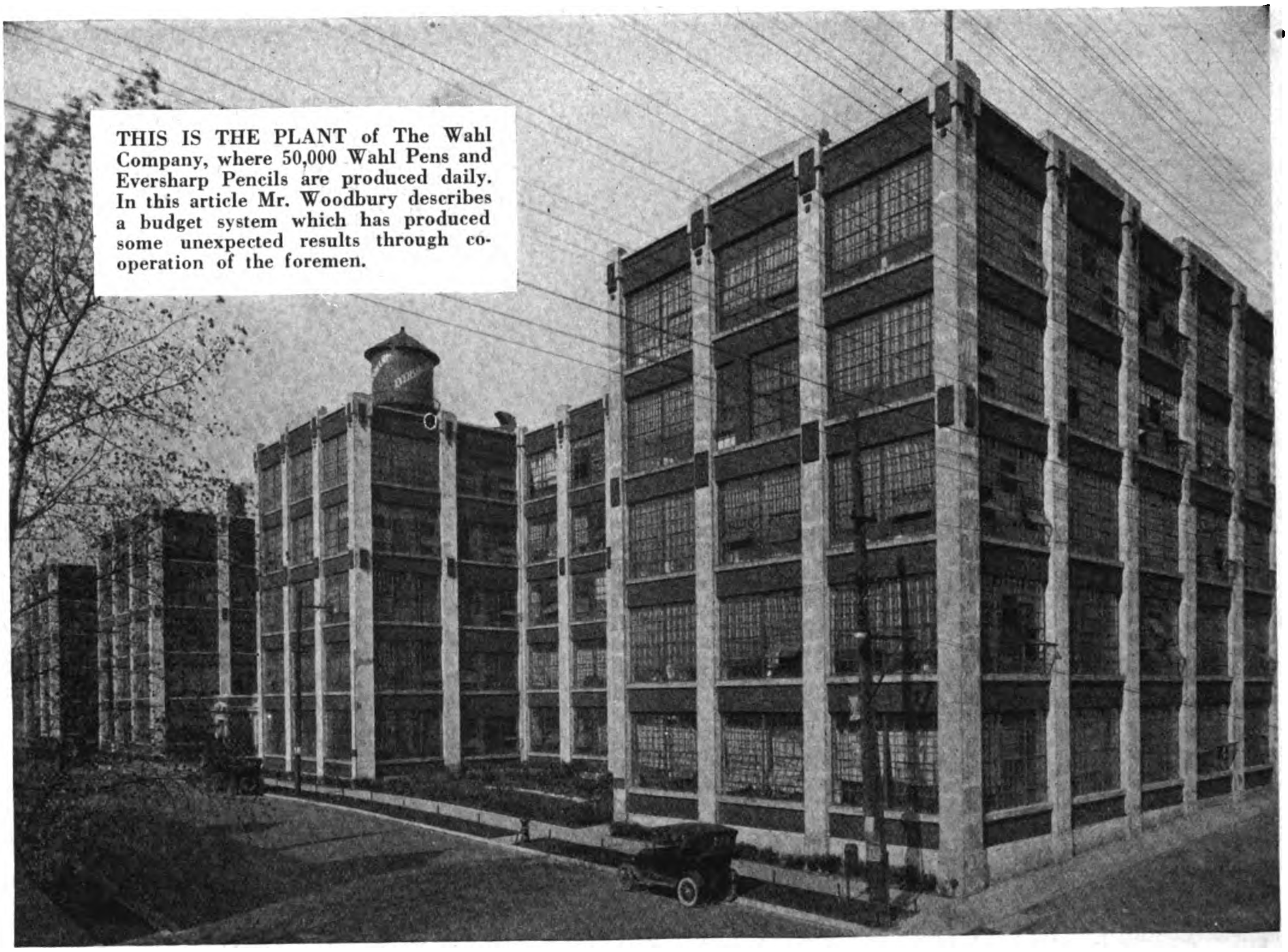
Before the wheat is ready to be prepared for shredding, it passes through twenty-two cleaning machines which remove all dust, weed seeds, straw and other foreign substances as well as shrunken, broken and defective grains. About 1,800 tons of this unusable material are removed annually in this cleaning process. The cleaned wheat then goes to large cylindrical tanks where it is cooked, meanwhile being agitated by revolving steel paddles. This treatment breaks up the starch granules in the center of the wheat kernel and renders them soluble and digestible. The outer coat of the grain of wheat is unbroken; so none of the nutritious elements in the wheat are lost in the process of cooking. The grain is then passed through a cooling and conditioning machine to remove any excess moisture which might interfere with the next operation of shredding. The conditioned wheat is fed into the hoppers of the shredding machines which are 88 ft. long and contain thirty-six pairs of steel rolls. These deposit the layers of shredded grain *(Continued on page 325)*

These illustrations show three steps in the making and packing of the shredded biscuit.
After passing under the thirty-six shredding machines, the layers of shreds are carried on a chain conveyor to the machine below which forms the biscuits and puts them on pans containing fifty-two. These pans are placed on the truck to be carried on to the oven shown at the right. The biscuits go through two sets of ovens and are baked and crisped and then are taken to the packing room shown at the heading of this article. The filled cartons are carried by conveyor from the packing tables to this special sealing machine, which not only seals up both ends of the box but also dries the vegetable glue immediately.









THIS IS THE PLANT of The Wahl Company, where 50,000 Wahl Pens and Eversharp Pencils are produced daily. In this article Mr. Woodbury describes a budget system which has produced some unexpected results through co-operation of the foremen.

Things That Can Be Accomplished by

Budgeting Repair and Maintenance Expenses

And the Details of a Plan Which Has Been in Operation for Two Years in the Plant That Makes Wahl Pens and Eversharp Pencils

By W. F. WOODBURY

Comptroller, The Wahl Company, Chicago, Ill.

IN THIS ARTICLE Mr. Woodbury points out that after two years' experience with the budget system for maintenance and repair work at the plant of The Wahl Company, the following advantages have been apparent: (1) Maintenance and repair costs can be closely estimated and controlled. (2) An accurate record is provided of the quantity and quality of the work of the Maintenance Department. (3) The foremen of the various departments have been led, by their desire to make a good showing in their departments, to take a deep interest in maintenance work and thus assist the maintenance department in many ways. (4) An incidental result has been the cutting down of power, heat, light and other like expenses, through prevention of waste. Performance of unnecessary maintenance or repair work is avoided. (5) A definite relation is maintained between production and maintenance work. (6) Although the budgets are made up a year in advance, provision is made for increasing or reducing the figures as necessary.

DURING the past two or three years the word "budgeting" or the term "budgetary control" has become so common that we are sometimes inclined to smile when we hear them used loosely and wonder if the person who is doing the talking really appreciates the true significance of the topic.

References to "budgeting" are now becoming almost as common as references to "efficiency" and if we are not careful, the former subject is liable to be just as much overworked as the latter. At the same time we must remember that the actual application of budgets to industrial works is in its infancy, although in some of the older organizations it has been in use many years. For instance some of the European countries, especially Great Britain, have had budgets and have operated with budget systems for many years, with more or less good results. Our own railroads have operated on practical budgets for years and it is probably owing to that fact that they have perhaps got more for their dollar than the average industrial works, although some of the larger organizations of the industrial class have,

especially during the past few years, been keyed up to a high state of efficiency.

Budgeting or budgetary control has more recently been adopted to a more or less extensive degree by considerable numbers of industrial organizations, both large and small. In fact many firms who really control their activities through budgets in one form or another would not even admit it.

Budgeting, like many other things, is good only if followed up—it is of absolutely no use whatsoever to set standards (because that is what budgeting is) if the standards set are not aimed at, and a checkup of the hits recorded and followed up closely.

In general, budgeting will vary considerably according to the size of the organization—in fact in a small one-man organization it may not even be necessary as most of the responsibilities are carried on the shoulders of one or two men who have the vital items of the business at their fingertips.

However, industry is getting away from the one-man organizations and tending more and more to amalgamations and larger concerns with great resources. Between these two extremes there are multitudes of firms of small, medium and large-sized organizations which need a budget or budgetary control to handle their business successfully. The matter of budgeting, while at times somewhat difficult of application, is of paramount importance.

All classes of overhead operations, from administrative and selling expenses to manufacturing and maintenance expenses, can be and should be budgeted. These and other expense budgets must be predicated on sales. Perhaps the hardest section of all to budget, and the one which will be considered in this article, is the repair and maintenance expense section, as there are so many phases and angles to consider.

In fact the matter of repair and maintenance is so comprehensive that it touches the entire organization and is of such vital importance to a concern of any size that the services of an expert engineer are not only advisable but necessary.

The equipment of a modern, large or fairly large plant is usually of such an intricate, often delicate nature, that to entrust the upkeep to anyone but an expert is laying up trouble. Further, so much can be done in the matter of heat, light and power costs that an experienced engineer with the aid of a budget can save large sums for a company. As a matter of fact, the making up of the budget depends to a large extent upon the power and other charts and records which are kept by the maintenance engineer.

In installing a budget system in The Wahl Company we realized that one of the hardest, if not the hardest item to budget was the one of repair and maintenance charges.

This can be realized from the fact that our factory contains 210,000 sq. ft. of floor space and is divided into forty departments. For producing an output of 50,000 pens and pencils daily there are employed many hundreds of machines of various types, ranging from small precision lathes to large rolling mills in which the ingots of gold, silver and other metals from which the pen and pencil bodies are formed, are rolled down preparatory to being drawn into tubes. Figs. 6, 7 and 8 show some of the types of equipment employed. A total of 233 electric motors, with an aggregate rating of 1,500 hp. is required to drive all of this equipment. Of these motors 140 are three phase, and 93 are single phase; they operate at 440 volts, and range in size

Fig. 1—Report form for weekly inspection of buildings and fire-fighting equipment.

The Wahl Co.

Fire Protection Report.

This Report must be Filed every Saturday Date..........

Sprinkler..........	Condition of fire extinguisher basement..........
Condition of Pumps..........	Condition of fire extinguisher 1st floor..........
Pounds pressure-1st section ( )lbs..........	Condition of fire extinguisher 2nd floor..........
Pounds pressure-2nd section ( )lbs..........	Condition of fire extinguisher 3rd floor..........
Pump switch on auto or hand control..........	Condition of fire extinguisher 4th floor..........
Amount of water in tank..........ft.	Condition of fire extinguisher 5th floor..........
Condition of tanks..........	Condition of water pails & barrels 1st floor..........
Lowest temperature of water in tanks..........	Condition of water pails & barrels 2nd floor..........
Lowest temperature in pent house..........	Condition of water pails & barrels 3rd floor..........
Condition of fire hose basement..........	Condition of water pails & barrels 4th floor..........
Stand pipe West..........	Condition of water pails & barrels 5th floor..........
Stand pipe East..........	Condition of tarpaulin..........
Valve at pump..........	Condition of entrance to stairs..........
Valve at pit..........	Condition of fire doors to stairs..........
Valve at tank..........	Condition of fire escapes..........
Drain valve..........	Condition of fire escape doors..........
Drain Valve..........	Condition of exits to streets..........
Valve No. 7 - open or closed..........	Condition of aisles to sprinkler risers..........
Valve No. 8 - open or closed..........	Condition of paper baling room..........
Condition steamer connections..........	Condition of bottom of elevator shafts..........
Are all sprinkler valves sealed?..........	Oily waste cans empty..........
	Inspected by..........
	O K'd by..........

Remarks.

....

....

....

....

FORM 1100—

REQUEST FOR BUDGET CHANGE

Comptroller,

Please revise yearly budget for Department No.______ Name______________________

Change acct. No.______ Name______________________ From $__________ To $__________

Change acct. No.______ Name______________________ From $__________ To $__________

Reasons for Changes

Original Department Budget $__________

Revised Department Budget $__________

Increase or Decrease $__________

Signed, ______________ Signed, ______________ DIV. HEAD Approved, ______________ GEN. MANAGER

Fig. 3—When conditions make it necessary to change the budget for any department this form is filled out.

This is made out in duplicate and the approval of the division head and of the general manager must be obtained before the budget may be changed. The original of the form goes to the comptroller's files, while the second copy is sent to the division head.

from ⅛ hp. to about 200 hp. rating.

We have a well-organized system of equipment and building inspection and maintenance, which is carried out under the direction of the maintenance engineer. Without going into all of the details it may be said that the maintenance schedule calls for weekly inspection of all motor and control equipment, and the like.

Also the maintenance engineer renders a weekly Fire Protection Report showing the condition of the sprinkler system, pumps, valves, fire extinguishers, escapes, doors, exits, etc., as detailed in Fig. 1.

In addition, the maintenance engineer makes periodical peak load and departmental motor load tests to make sure that the equipment is properly loaded and that no unusual conditions have developed. No additional machinery is added to any department without first consulting the engineer's records to ascertain if the present motor equipment will take care of the added capacity. Likewise, charts are kept on the consumption of electrical energy, gas, coal, oil and so forth.

NO. 1040

THE WAH[illegible]COMPANY
ANALYSIS AND COMPARISON [illegible] DEPARTMENTAL EXPENSES
MANUFACTURING DEPARTMENTS

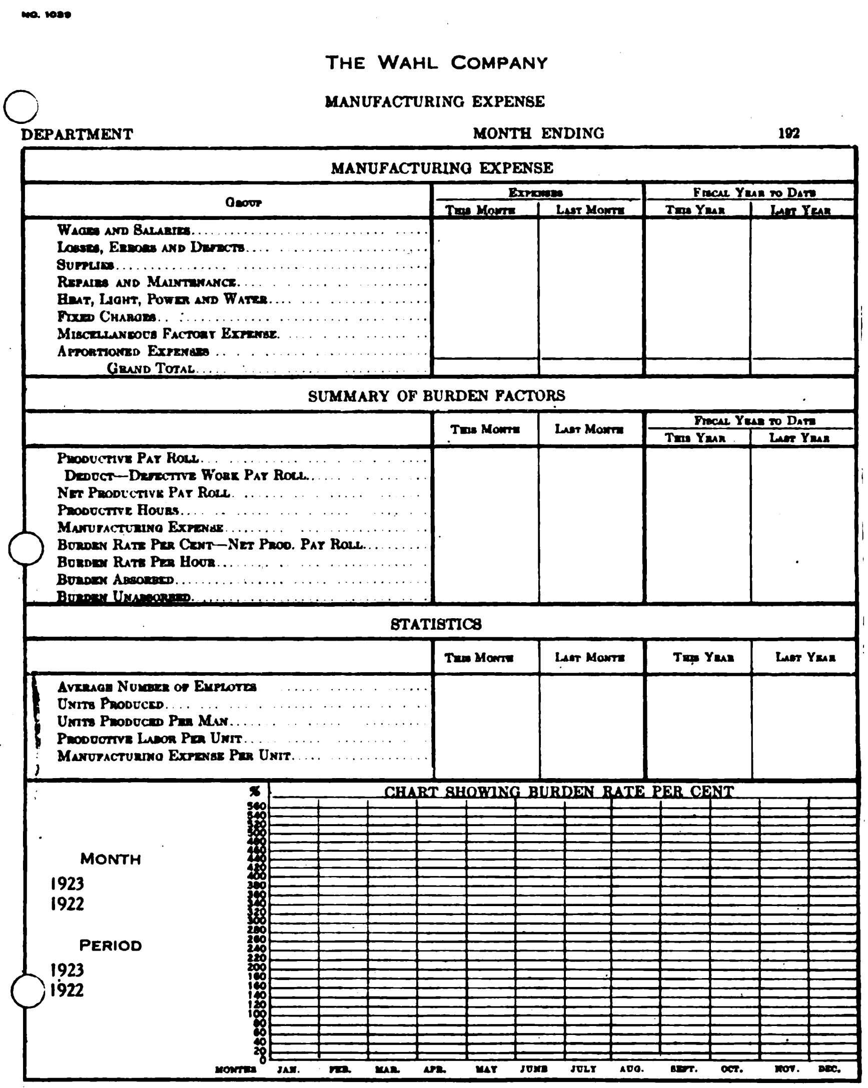
DEPARTMENT PERIOD

Acct. No.	Account	Actual Amount	Estimated Amount	Over or Under Estimate	Same Period Last Year
450	Foremen and Assistants				
451	Clerks and Messengers				
452	Timekeepers				
454	Timestudy and Ratesetting				
455	Production Clerks, Storekeepers, etc.				
456	General Inspection				
457	Engineering & Experimental				
458	Cleaners, Oilers & Janitors				
459	Watchmen & Elevator Opers				
460	Matrons and Nurses				
462	Student Labor				
463	Folding Circ. & Filling Cart's				
464	Rearrangement, Mchy., Labor				
465	Sundry Labor				
466	Tool and Die Setting				
467	Unapplied Productive Labor				
	Total Wages and Salaries				
480	Defective Workmanship				
481	Sick, Injured & Absent Emp.				
482	Waiting Orders, Stock, etc.				
483	Overtime Excess & Allces				
484	Pencils, Pens & Sundries Lost				
485	Reconditioning Scrap for Sale				
486	Def. Mat'l Not Ret'd to Sup's				
487	Change in Design				
488	Reconditioning Finished Stock				
	Total Losses, Errors & Defects				
490	Stationery & Office Supplies				
491	Cutting Oils, Cleaning Rags, etc.				
492	General Supplies				
493	Plating, Buff. & Polish Sup's				
494	Janitor's Supplies				
495	Medical Supplies				
496	Experimental Supp. & Mat'l.				
497	Rearrangement Mchy., Lbr.				
498	Boxing, Wrapping & Packing				
	Total Supplies				

Acct. No.	Account	Actual Amount	Estimated Amount	Over or Under Estimate	Same Period Last Year
	REPAIRS & MAINTENANCE				
500	Buildings and Grounds				
501	Mchy., Power, Tools & Appli.				
502	Shop Equipment				
509	Reps. to & New Loose & Hand Tools				
510	Patts., Dies, Jigs & Temp				
511	Furniture & Fixtures				
	Total Reps. & Maintenance				
	HEAT, LIGHT, POWER AND WATER				
540	Fire Insurance				
541	Liability Insurance				
542	Taxes, Real Est. and Personal				
	Depreciation of				
543	Buildings				
544	Mchy., Power Tools & Appli.				
545	Shop Equipment				
546	Patts., Dies, Jigs & Temp				
547	Furniture and Fixtures				
	Total Fixed Charges				
560	Traveling and Entertaining				
561	Telephone and Telegraph				
562	Gratis Pens, Pencils & Sund.				
563	Expense Taking Inventories				
564	Fgt., Express & P.-Post Unapp				
565	Meals for Employees				
566	Laundry				
567	Sundries				
568	Subs, Memberships & Dues				
	Total Misc. Factory Exp.				
	Total Direct Dept. Expense				
	Apportioned Charges				
	Grand Total Dept. Expenses				

Fig. 2—Foreman's report sheet, which is given out every month and shows the charges made against each department.

These reports are sent to all department foremen and have been of much value in fostering close co-operation between the foremen and the maintenance department, and reducing power, heat and light costs by prevention of waste.



NO. 1039

THE WAHL COMPANY

MANUFACTURING EXPENSE

DEPARTMENT MONTH ENDING 192

MANUFACTURING EXPENSE

Group	Expenses		Fiscal Year to Date	
	This Month	Last Month	This Year	Last Year
Wages and Salaries				
Losses, Errors and Defects				
Supplies				
Repairs and Maintenance				
Heat, Light, Power and Water				
Fixed Charges				
Miscellaneous Factory Expense				
Apportioned Expenses				
Grand Total				

SUMMARY OF BURDEN FACTORS

	This Month	Last Month	Fiscal Year to Date	
			This Year	Last Year
Productive Pay Roll				
Deduct—Defective Work Pay Roll				
Net Productive Pay Roll				
Productive Hours				
Manufacturing Expense				
Burden Rate Per Cent—Net Prod. Pay Roll				
Burden Rate Per Hour				
Burden Absorbed				
Burden Unabsorbed				

STATISTICS

	This Month	Last Month	This Year	Last Year
Average Number of Employes				
Units Produced				
Units Produced Per Man				
Productive Labor Per Unit				
Manufacturing Expense Per Unit				

CHART SHOWING BURDEN RATE PER CENT

MONTH
1923
1922

PERIOD
1923
1922

%

MONTHS JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.

Fig. 4—Recapitulation of manufacturing expenses, burden factors and statistics.

This sheet is made out monthly and goes to the factory executives and general management.

We are convinced that keeping a plant clean, sanitary and well-ordered saves money in the long run and we make provision for periodical general house-cleaning and painting, in addition to the usual janitor service.

We know that in order to produce a given output, a certain number of motors and other equipment will have to be operated. Consequently, the budget is predicated on estimated sales, taken in conjunction with past experience, and in estimating or budgeting the maintenance expenses, the accounting records which we have and the charts which are kept by our maintenance engineer are of inestimable value. From these charts we are able to budget a year ahead and set up the figures for monthly allowances. The monthly budgets for general maintenance work are, of course, subject to change as the year progresses, inasmuch as our records may show that owing to increases or decreases in sales and production it is necessary to adjust our overhead expenses.

On the other hand, some parts of our maintenance can be handled more accurately and with much less difficulty than others. For instance, the cost of cleaning and painting can be estimated very closely and a certain specified allowance set aside to cover these items during the year.

As will be seen from the Foreman's Report, Fig. 2, which will be referred to later, each of the various items that come under the head of maintenance and repairs is given an account number.

The estimated cost of doing the work represented by each account number is then determined. As the maintenance and repair labor and material tickets are turned in, they are charged against the proper account number.

The maintenance budgets as well as all the other budgets of the organization require the approval of the general manager and reports are rendered to him monthly both summarizing and detailing the expenses of the organization by totals, by classes of expenses and by departments, in such a manner that overruns and deficiencies are readily brought to his attention. Among these reports is a recapitulation of manufacturing expenses, burden factors and so on, shown in Fig. 4.

As this is only our second year of

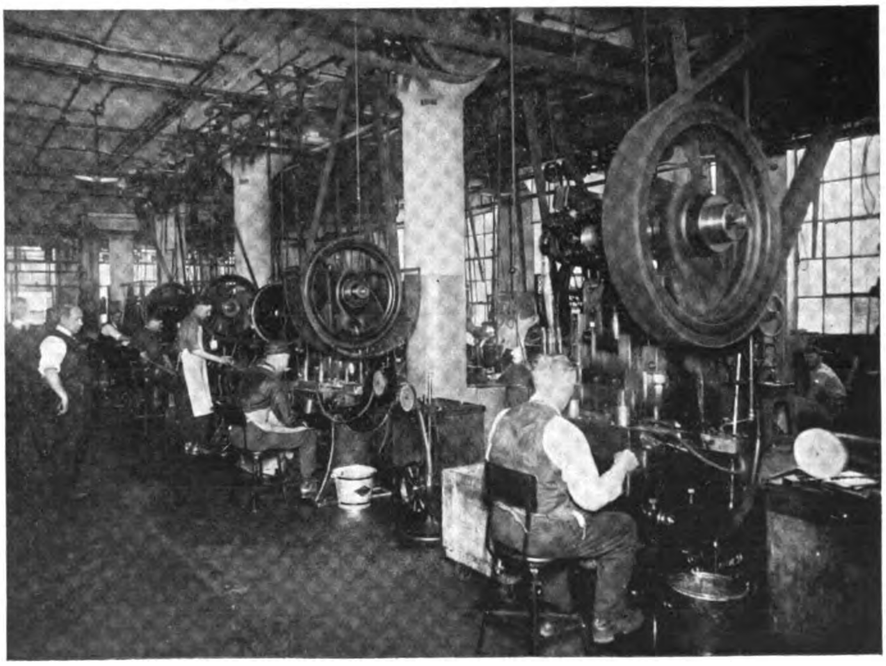


Fig. 5—Punch presses and other heavy equipment likewise enter into the manufacture of pens and pencils.

Fig. 6—Part of the pen assembly and machining department.
The equipment in this department is light and consists for the most part of precision lathes and fine grinding devices.

operation under a budget system, it will be realized that it is as yet far from perfected, but already we are seeing extensive benefits. Incidentally, the budgeting of operating expenses in general has had a bearing in itself in keeping the repair and maintenance charges down, for a foreman realizes that if he allows his machinery to run down, subsequent breakdowns cost his department money. Consequently, notwithstanding the fact that, as mentioned before, our maintenance engineer has a very thorough, systematic inspection layout, is continually making motor and other tests, and keeps running charts on the consumption of gas, oil, coal and so on, he now has allies in all the foremen in the matter of keeping down maintenance costs.

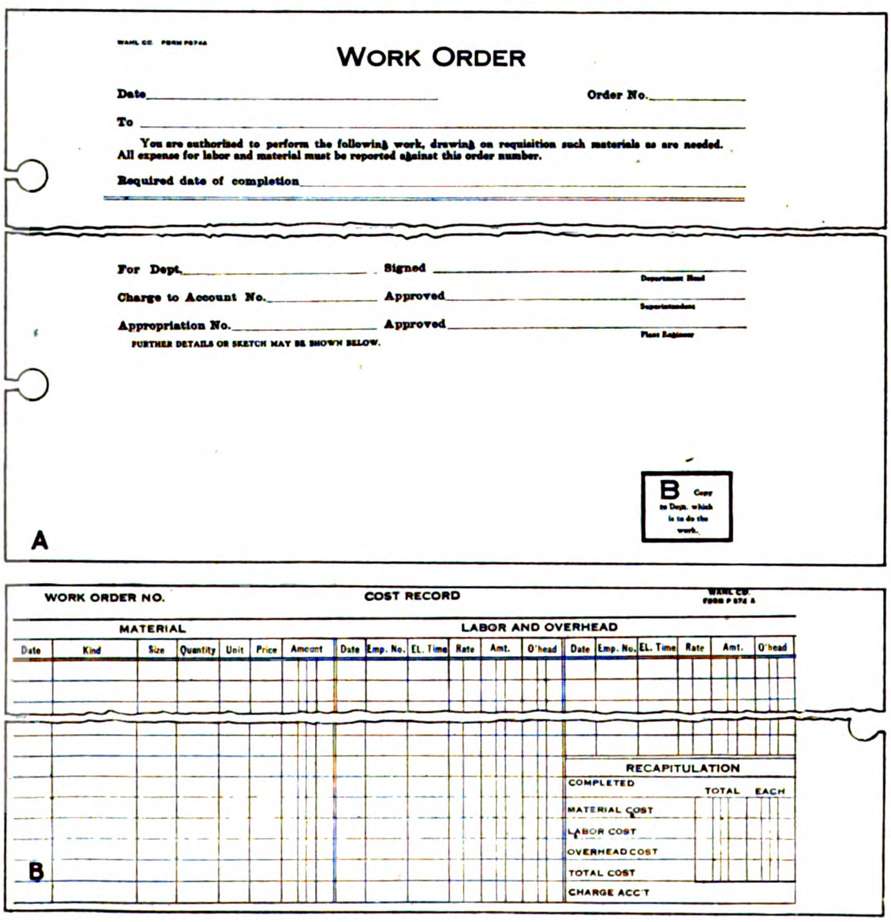
The matter of foreman's reports has been discussed at length by many accountants and accounting organizations and there are many differences of opinion as to just how much information should be supplied to the foreman. We believe in giving the foreman a report of the overhead expenses pertaining to his department regardless of whether or not he has actual physical control over them and we have a system of monthly foreman's reports comparing the actual showing by account with the budget, detailing over-runs and under-runs, and also comparing the present standing with last year's; on this report the expenses are detailed by sections or classes as follows:

(1) Wages and salaries.
(2) Losses, errors and defects.
(3) Supplies.
(4) Repairs and maintenance.
(5) Heat, light, power and water.
(6) Fixed charges.
(7) Miscellaneous.
(8) Apportioned from other departments.

The foreman's report form is shown in Fig. 2.

Although the foreman really has no actual personal control over the Repairs and Maintenance section, or at least not wholly so, or over the Heat, Light and Power section, we have found that by suggestions from the foreman and by check-ups made by him we have been able to realize savings which would not have been possible otherwise. The interest which the foremen take in these reports is remarkable, and they have paid for themselves many times over.

With our series of reports we are able to keep a close check against the budgets and *(Continued on page 354)*



WORK ORDER

Date ______ Order No. ______

To ______

You are authorized to perform the following work, drawing on requisition such materials as are needed. All expense for labor and material must be reported against this order number.

Required date of completion ______

For Dept. ______ Signed ______ Department Head

Charge to Account No. ______ Approved ______ Superintendent

Appropriation No. ______ Approved ______ Plant Engineer

FURTHER DETAILS OR SKETCH MAY BE SHOWN BELOW.

B Copy to Dept. which is to do the work.

A

WORK ORDER NO. COST RECORD

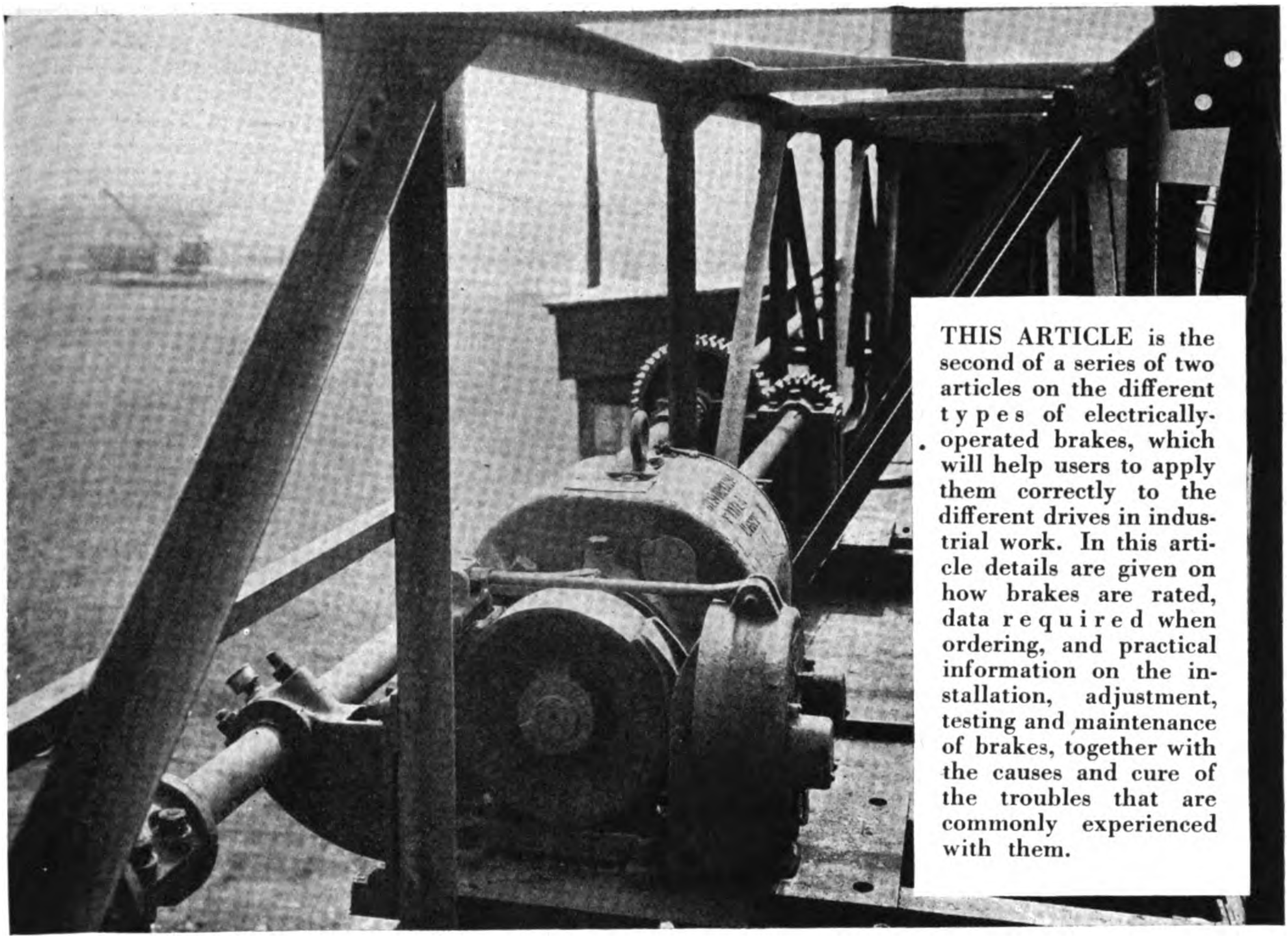
MATERIAL							LABOR AND OVERHEAD											
Date	Kind	Size	Quantity	Unit	Price	Amount	Date	Emp. No.	EL. Time	Rate	Amt.	O'head	Date	Emp. No.	EL. Time	Rate	Amt.	O'head

RECAPITULATION

COMPLETED	TOTAL	EACH
MATERIAL COST		
LABOR COST		
OVERHEAD COST		
TOTAL COST		
CHARGE ACC'T		

B

Fig. 7—Before any maintenance work is performed for a department, authorization must be obtained on a form like this.
This form, *A*, is made out in triplicate and covers both maintenance work and additions to plant. On the reverse side, *B*, of the *Accounting Department's* copy, the material and labor for doing the job are posted and then charged to the department for which the work was done. This form is originated by the department head and must be approved by the superintendent and plant engineer. One copy of the order goes to the files of the department which originates the order; the second copy goes to the department for which the work is being done and the third copy is filed in the *Accounting Department*.



THIS ARTICLE is the second of a series of two articles on the different types of electrically-operated brakes, which will help users to apply them correctly to the different drives in industrial work. In this article details are given on how brakes are rated, data required when ordering, and practical information on the installation, adjustment, testing and maintenance of brakes, together with the causes and cure of the troubles that are commonly experienced with them.

Fig. 1—Series-wound, direct-current brake operating on the bridge motion of a 20-ton gantry crane. This brake is separately mounted on the bedplate on which the motor is installed. By removing the one pin at the top of the magnet, the rod which connects the magnet to the opposite brake shoe arm may be lifted and the hinged arm swung back to permit the removal of the brake wheel and motor armature. This is done without disturbing in any way the setting of the brake or the alignment between the brake and the motor.

Details of the Selection And Operation of

Brakes Used to Retard Or Hold Rotating Parts

Of Cranes, Hoists, Elevators, Turntables, Line-shafting and the Like to Prevent Overtravel, to Stop at Definite Points, Hold Loads and Make Emergency Stops

By ARTHUR J. WHITCOMB

Associate Editor, Industrial Engineer

A BRAKE is a device for retarding or stopping rotary motion by friction. An electric brake is one which is set by mechanical means and released electrically. In the first article in the June issue, brakes were classified according to mechanical form; that is, as to the mechanical methods of retarding or holding the rotating part. In this same article, brakes were also classified as to their electrical characteristics; that is, according to the method used to release the brakes. In addition, brake wheels, brake bands and brake shoes were discussed. In the following article details concerning the construction and use of brake linings are given together with the rating, selection, testing and operation of electrically-operated brakes.

If steel or iron brake shoes or bands were pressed directly against a steel or iron brake wheel, considerable wear would take place, howling and squealing would result and the friction torque resulting between the two would not be very high. Brake linings are used primarily to secure a higher frictional coefficient and thus obtain more rapid braking. The difficulty lies in finding a material that has a high enough coefficient of friction and at the same time will not burn itself up by the heat generated through the braking action.

Although several kinds of brake linings were mentioned in the preceding article, there is only one kind of lining in common use on electric brakes at the present time. That is the woven asbestos lining, more commonly known by various trade names.

In making woven asbestos brake lining only the highest grade of long,

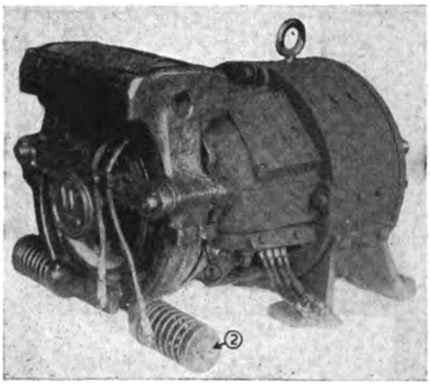


Fig. 2—Brake bolted to machined lugs on the motor end-bracket.

This makes a compact unit of motor and brake. The brake has two adjustments: adjustment at (1) compensates for wear of the linings; adjustment at (2) changes the value of braking torque or intensity. At the other end of the brake, opposite (1) and (2) are similar adjustments for the opposite shoe and spring.

tough asbestos fibers are used. These are mixed with about 10 to 12 per cent of cotton to increase the strength, and spun around brass wires to make threads. The brass wire is used to add tensile strength and greater wearing quality. After the threads are woven into fabric, it is impregnated with special compounds which give the lining the proper coefficient of friction and at the same time render it impervious to the action of water, oil, grit or other foreign substances. The lining is then baked in ovens, folded in plies to secure the proper thickness, and run through heavy rolls to compress it to the required size.

Carefulness in attaching brake linings cannot be over-emphasized. The rivet heads should be sufficiently countersunk so that they will not bear on the metal drum; the lining should be stretched tight so that there will be no high-spots; and the rivets should be thoroughly upset.

The limiting temperature which most lining materials will stand is about 200 deg. C. Soft fabric lining materials give more friction, but they wear faster and compress. Hard fabric linings do not wear as fast and consequently the brake does not require as frequent adjustment.

Brakes are rated in pounds retarding torque at 1-ft. radius on the brake-wheel shaft. The term "retarding torque" is only applied to a revolving wheel condition. As the coefficient of static friction is higher than the sliding coefficient, the holding torque of a brake, when the wheel is at rest is higher (about 10 per cent) than the retarding torque.

The retarding torque that a brake will develop depends upon the amount of weight or the extent the springs are "set up." This in turn depends upon the ability of the solenoid or magnet to release them. Where an intermittent-duty coil is used, it may be worked harder and made more powerful; consequently the brake may be "set up" tighter and its retarding torque increased.

A brake retarding a given torque from a high speed will dissipate more energy (i. e., generate more heat) than one retarding the same torque at a lower speed. One of the limitations on the rating of a given brake is its ability to dissipate the mechanical energy which is converted into heat. Consequently brakes are given a maximum horsepower rating which signifies the highest-horsepower motor with which the brake may be expected, under average conditions, to perform without excessive heating and with reasonable shoe wear.

As the coil of a series brake carries the motor current it must be designed accordingly. Brakes are rated in the same manner as the motors with which they are to be used.

Fig. 3—Motor-operated, alternating-current, shoe brake in service on an elevator.

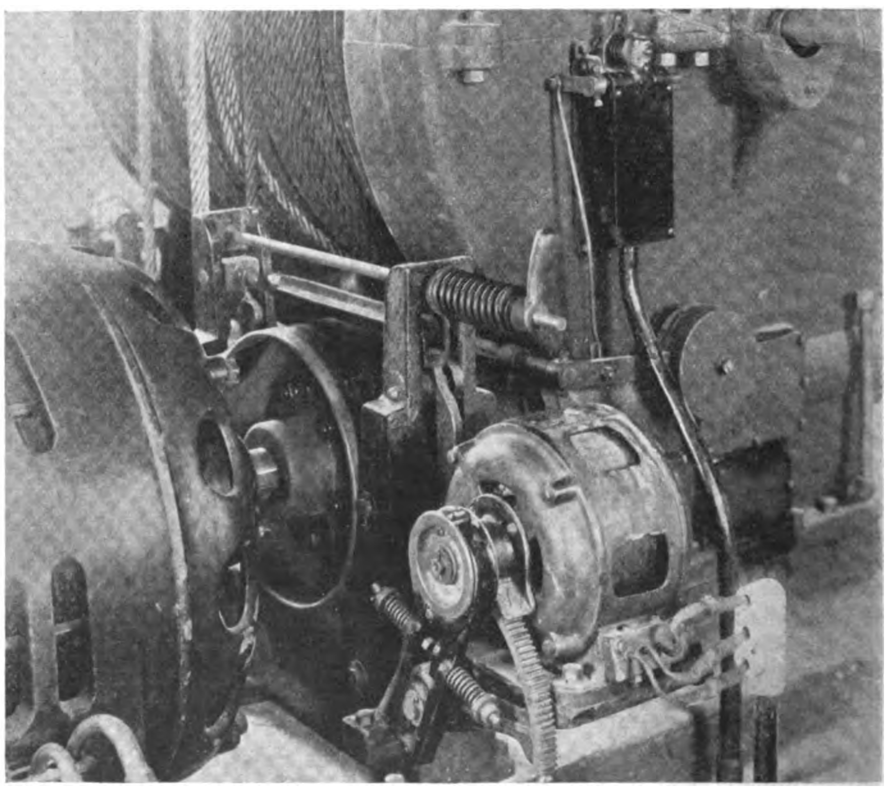
This brake is fastened directly to the bedplate on which the motor is mounted. As can be seen, the torque motor operating the brake is mounted on the brake frame.

The usual ratings are on a 30-min. or a 60-min. basis for intermittent service and a continuous-duty rating. Intermittently-rated brakes will release on 40 per cent of rated current; continuously-rated brakes will release on 80 per cent of rated current. Series brakes, once released, will stay open with as low as 10 per cent of rated current.

Shunt brakes are given either an intermittent-duty rating or a continuous-duty rating. The coils of some shunt brakes are wound for full-line voltage; others are wound for less than line voltage. In the latter case the coil is put across the line to release the brake; when the brake is released, a resistor is automatically inserted in series with the coil so as to prevent the coil from overheating. Shunt brakes, due to the inductance of the shunt coil, are inherently sluggish in action; using coils wound for less than line voltage makes the brake action faster.

Brakes are selected on the basis of the retarding torque they must develop; also the area of the brake lining must be given consideration. Ordinarily a brake is selected having a retarding torque equal to full-load motor torque. The full-load motor torque may be determined by the following formula:

Torque (in. lb. ft.) = (5,250 × hp.) ÷ r.p.m., where hp. = full-load horsepower rating of motor and r.p.m. = the speed of the brake



wheel in revolutions per minute.

Sometimes a brake with a retarding torque of less than full-load is sufficient, particularly if the brake may be allowed several seconds in which to stop the motor; again, however, a brake with a rating of 150 per cent of full-load torque is selected so as to give a very quick stop, to provide a higher factor of safety, or to hold an occasional heavy load.

When the service to which the brake is to be subjected is unusually severe the heat dissipating ability of the brake becomes the determining factor in its selection. If the horsepower rating of the driving motor exceeds the limiting horsepower rating of the brake (the size of which has been determined by the torque formula), then in order to secure sufficient area of brake lining to insure maximum economy, the brake should be selected on a horsepower basis rather than by the torque rating.

Most shoe brakes are manufactured in sizes up to 400 hp. and 3,200 lb.-ft. torque on the 30-min. rating. Standard lines of disc brakes do not run to such large sizes. In general, the limiting horsepower rating is about 120 hp. and this size will develop a retarding torque of 1,030 lb.-ft. on the 30-min. rating. One manufacturer, however, makes a disc brake with a 250-hp. rating.

The speed of the shaft to which the brake is to be attached should not exceed the maximum safe speed for which the brake is designed. Otherwise a brake-wheel explosion might result with attendant danger to men and equipment.

The manufacturers usually require the following information when brakes are ordered:

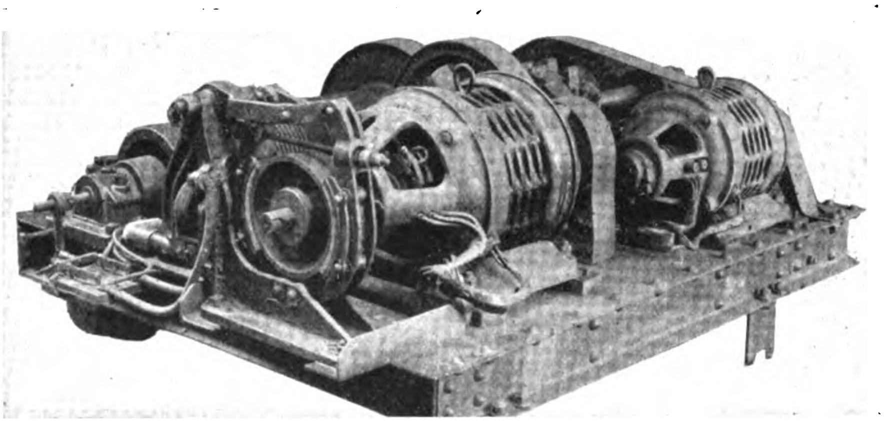
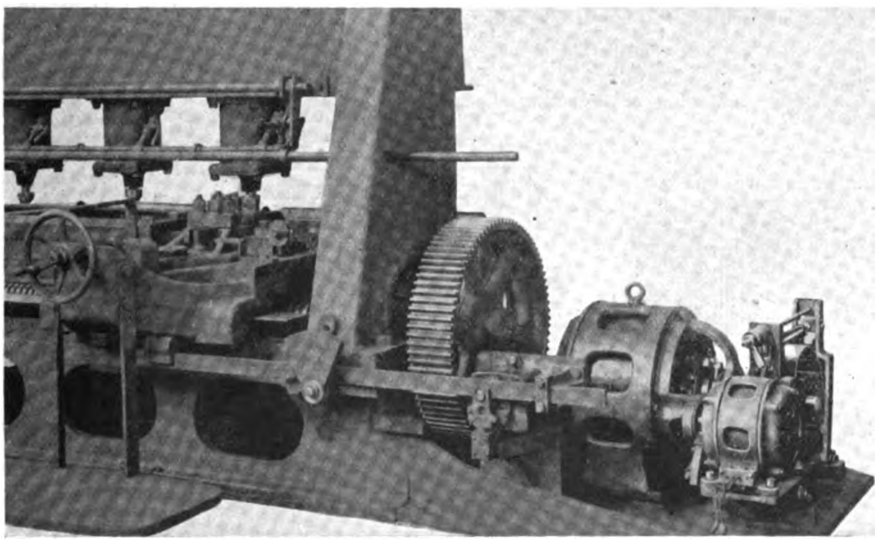


Fig. 4—This is an alternating-current, shoe-brake that is operating on the hoist motion of a crane.
The trolley carriage was not wide enough to mount the brake directly on it; so two angles were bolted to the trolley frame as is shown. The brake was bolted to the two angles.

(1) Motor rating: type; full load speed.
(2) Speed of shaft on which brake is to be mounted.
(3) Line voltage: maximum volts; minimum volts.
(4) If d.c.; type of brake winding (series or shunt).
(5) If a.c.; frequency; number of phases.
(6) Winding duty; intermittent or continuous.
(7) Exact bore and keyway in hub. If taper, send sketch or motor frame data.
(8) Nature of load and duty cycle, if available.

Most brakes are mounted separately on the motor bedplate. A few are attached directly to the motor frame. In Fig. 2 is shown a brake attached directly to the motor frame. Spring-operated brakes can be mounted on the floor, wall or ceiling. Gravity-operated brakes, obviously, must be floor mounted. When installing a shoe brake, care should be taken that the brake wheel is exactly centered between the brake arms when the brake is in the released position; also that the brake shoes are parallel to the face of the brake wheel. Likewise in the case of a separately-mounted disc brake, care must be taken that the stationary plates are parallel to the rotating plates. In the case of a band brake the band must be circular with no kinks so that all of its working surface is effectively applied to the face of the brake wheel. If the brake is not properly lined up, the brake linings may bear in only one or two spots, causing very high pressure at these points, which would result in inability of the brake to hold the load and cause slippage.

Fig. 5—This plate planer is equipped with a motor-operated, alternating-current shoe brake.
On this planer the tool rest travels, instead of the planer bed. The tool rest is shown at the left near the hand wheel. Below the hand wheel is the operator's platform which also travels with the tool rest. At each end of the travel of the tool, the brake is required to absorb the inertia of the tool carriage. The brake is the same type as the one shown in Fig. 3.



The electrical connections of a brake are very simple. The series-wound brake is usually connected to the line side of the series field of the motor. It may be placed elsewhere in the circuit, but this is the more common connection. Some shunt brakes are connected across the line, while others have a series resistor with which they are shunted across the line. If the shunt brake is provided with a discharge resistance, it, of course, should be paralleled with the shunt coil.

All brakes are provided with a means of varying the braking intensity. This is accomplished by varying the weight or the length of the lever arm on which it hangs, or if it is a spring-set brake, by changing the compression of the spring. In addition all brakes are provided with an adjustment for the shoe, disc or band clearance. A change in this adjustment also changes the air gap of the magnet or the stroke length of the core of the solenoid. This ad-

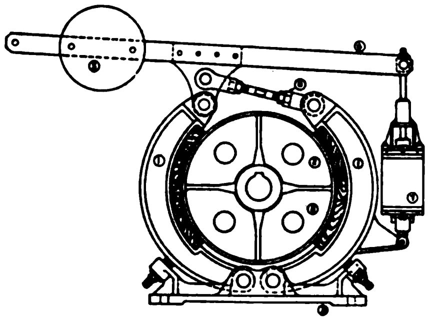


Fig. 6—There are three adjustments on this solenoid-operated brake.

The shoe clearance and the air gap in the solenoid are simultaneously adjusted at (6). The clearance between the two shoes and the brake wheel is equalized by the adjusting screws at each end of the brake frame (3). The braking intensity is controlled by moving the weight (5) along the lever arm, that is marked (4).

justment should be the minimum that will fully release the brake wheel. Making this adjustment minimum gives a minimum air gap which gives a stronger magnet pull and in turn enables the magnet to release a brake with heavier braking power caused by setting up the compression springs or changing the weights. Details of these adjustments are given in the captions to Figs. 6, 7, and 8.

Assigning Responsibility for the Inspection of Brakes

Brakes should be inspected at regular intervals, varying with the conditions under which the brake is operating. A brake operating at its full-torque rating will require adjustment more often than a brake that is operating at only 50 per cent of its torque rating. This time interval can only be determined by experience. If the brake is depended upon to hold heavy loads under emergency conditions or is relied upon to hold the bridge of a crane during strong winds, the inspection should be quite frequent and very thorough.

The question often arises as to who should be responsible for the inspection and maintenance of the electric brakes. In the case of a crane, the adjustment of the brakes is often left to the operator. The result is that the brakes are usually set too tight and cause severe racking of the gears and shafting. Often the responsibility is split between the mechanical and the electrical departments. The mechanic usually keeps the brake bands in good order but seems unable to understand the relation existing between the air gap, the pull of the magnet and the shoe clearance, with the result that the brake does not function as efficiently as it should.

Besides the division of responsibility provides a convenient opportunity for "passing the buck." The adjustment and maintenance of brakes is really a very simple proposition if the workman realizes exactly what he is trying to do. The motor inspector from the electrical department does understand this and it will be found that the most satisfactory operation will be obtained if the entire responsibility for the brakes is placed upon him.

There are not many sources of trouble for electric brakes. Probably the most common complaint is that the brake fails to hold the load or does not stop the machinery soon enough. This is due to incorrect adjustment of the braking intensity. On spring-operated brakes the spring compression should be increased and on gravity-operated brakes either the weight should be increased or the length of the lever arm through which the weight acts should be increased.

Another cause of trouble is that the brakes do not release. This is usually due to the fact that the brake lining has worn to the point where the *(Continued on page 328)*

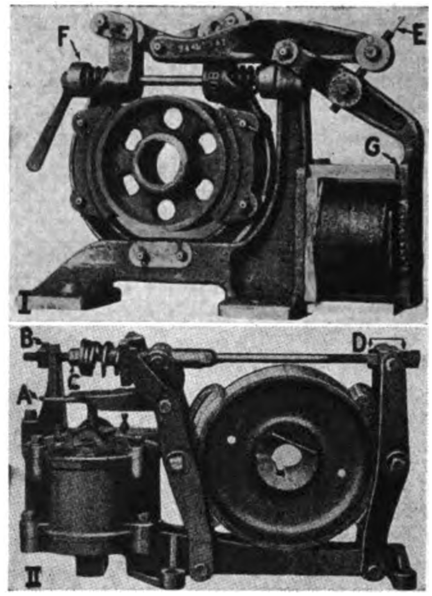
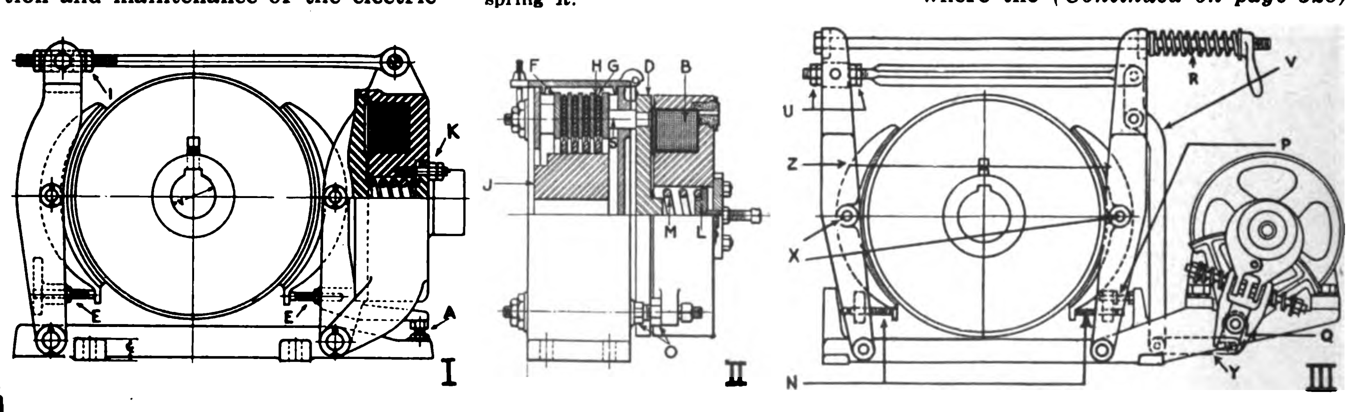


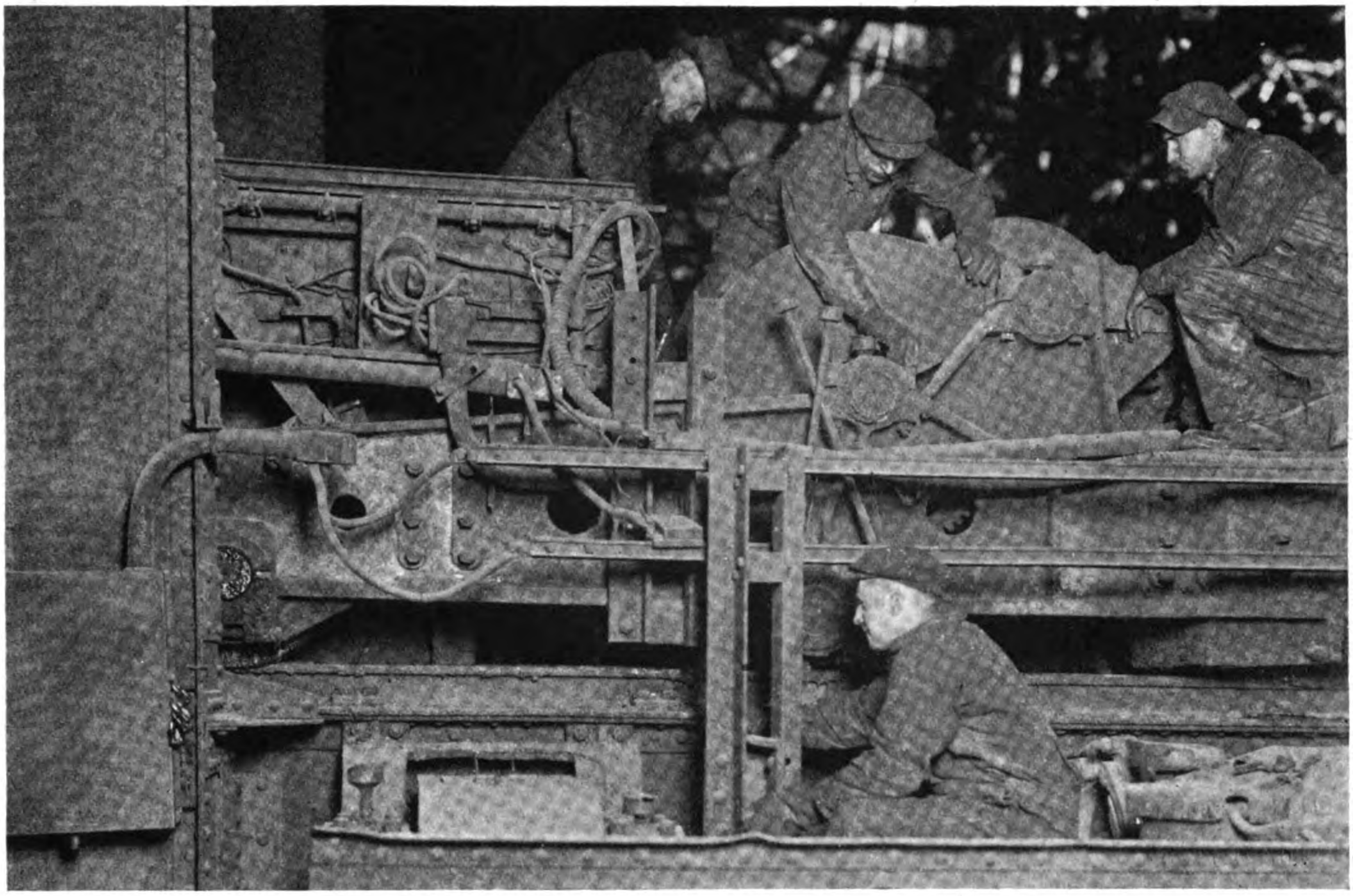
Fig. 7—The brake shown in illustration I has only two adjustments.

The adjusting screw at *E* regulates the air gap at *G*; this in turn determines the shoe clearance when the brake is released, for the movement of the shoe is directly proportional to the movement of the armature through the air gap at *G*. The braking intensity or holding power is adjusted by the handled nut *F*. This compresses or relieves the compression on the spring. In the brake shown in II, there is a pointer at *A*, moving over a scale placed immediately behind it. When the brake is set, the pointer should be in line with the lower of the two marks on the scale. As the lining on the brake shoes wears, *A* will fall below the lower mark. By the adjustment at *D*, the pointer *A* can be brought back to the mark. The clearance between the shoes and the brake wheel is adjusted at *D*. The braking force is determined by the adjustment of the nut *C* against the spring.

Fig. 8.—Method of adjusting three different types of brakes.

In illustration I is shown a series-wound, direct-current, magnet-operated shoe brake. The shoe clearance is adjustated at *A*, *I* and *E*. With the brakes released, the stop screw *A* is adjusted so that a $\frac{1}{32}$-in. feeler can be inserted between the wheel and the right-hand shoe at the center line. The left-hand shoe is similarly adjusted by the adjustment at *I*. The screws *E* are adjusted so that with the brake released the shoes will have the same clearance at top and bottom. The braking intensity is varied by the adjustment of *K*. In illustration II is shown a direct-current disc brake. Adjustments to compensate for the wearing of the friction elements is accomplished by the adjusting nuts at *O*. Braking intensity is controlled by adjusting the setscrew bearing against the collar *L*. In illustration III is shown a motor-operated, alternating-current brake. This brake is quite similar to the brake in illustration I except that it is motor operated instead of magnet operated. The adjustment at *P*, *U* and *N* are the same as at *A*, *I* and *E* respectively in illustration I. These adjustments compensate for wear of the friction elements. The braking intensity is controlled by tightening or loosening the spring *R*.





Padlocked switchboxes, such as this, protect men and machines. Starting a partially dismantled machine may damage the machine as well as injure the repair man. Each of the four men has his lock on the switch box.

Responsibilities and Activities of the

Maintenance Department In Industrial Safety

Together with a Discussion of the Value of Safety and Some Precautions Which May Be Taken to Protect Maintenance Men at Their Work

By H. W. DONALD

District Manager of Engineering, American Mutual Liability Insurance Company of Boston, Boston, Mass.

PLANT MAINTENANCE differentiates the well-kept, safe, successful, going concern from its ill-kept unsuccessful neighbor. Those plants which do not pay sufficient attention to proper maintenance are more often shut down for repairs, and subjected to repeated interruption of production while machines are "fixed" or "nursed" along to be patched up out of hours, or burnt out by accumulation of debris due to slack housekeeping. It is noteworthy that such plants generally have a pronounced shifting of personnel because they are shunned by good employees. In surveying the progress in industrial activities during the past ten or twenty years, one is impressed with the greater attention given to maintenance along with safety work since Workmen's Compensation has become an expensive factor in industry.

> PERHAPS no other employees are exposed to more and varied accident hazards than are the maintenance workers in the industrial plants. Mr. Donald describes in this article some of the precautions maintenance men can take to protect themselves and fellow workers as well as methods by which they can help in reducing the cost of accidents.

The cost of Workmen's Compensation, which is an insurance premium in most plants, is based upon a schedule rating which is affected largely by the physical condition of the individual plant. A swing of 30 to 40 per cent up or down in the insurance cost is not unusual between two plants similar in product, equipment and size. Observation has shown that a large proportion of accidents is still directly attributable to poor maintenance of walks, ways, machinery and plants, just as a large part of depreciation of plants and equipment is due to poor maintenance rather than to faulty design or use.

Maintenance may relate merely to keeping the wheels turning with a roof above them. It may relate to the intricate adjustment and set-up of machines in process of production, or it may relate to the comfort

and safety of the workers. Their requirements, although in the past considered on a flexible basis, are found every day to demand more rigid standards if success is to be achieved in present-day competition. This arises not so much from the demands of the employees as from the scientifically demonstrated rules of efficiency. Uncongenial working conditions increase labor turnover. A serious accident may close down, or at the very least slow up, a department, or the entire works, according to the prevailing temperament of the force, and every injury suffered invariably spins a thread of antagonism which is undesirable under any labor conditions.

Before going further into a discussion of the part that maintenance takes in accident prevention, it may be well to state that safety work consists of two elements: (*a*) Education of the employe into an appreciation of the importance of being a careful worker and what it means to him, and (*b*) safeguards and other protective measures which make it difficult for a man to get hurt. Although the maintenance workers can perform an important service in promoting the education of the other workmen, largely by the example of their own carefulness and attitude toward all safety activities, they are more closely connected with the second of these divisions of safety work.

While it is the duty of the management to see that adequate lighting, ventilation, proper working temperature and humidity, and sanitation are provided and that fencing of moving machine and power transmission elements, protection of floor and wall openings, and repair of floor and wall surfaces and structures where patent defects exist, are made as necessary, the maintenance organization, however, is usually called upon to install and look after the operation of safeguards as well as the equipment and to make any other changes necessary. Regular inspection with adequate records to prevent failures in plants and equipment from latent defects are an important part of the control of these activities.

When considering maintenance and its application to health and safety, there are two sides to consider: The safety of the repairman himself, and the safety of the other employees. Perhaps no group of workers is more frequently brought within the line of personal danger than the maintenance force.

To a certain extent, maintenance men may be put into one class for the purposes of present consideration, as the hazards are similar to woodworkers, metal workers, pipe and steam fitters, electricians, builders, machine fixers and set-up men in innumerable industries. A certain knack or genius is necessary to the job, an ability to make things go, and the dangers are very much alike.

Formerly, under the assumption of risk of the common law, the repairman was not protected if injured while in the process of repairing a machine, and he frequently had difficulty in obtaining damages for injuries so sustained. This is not so today, and he is compensated for injuries occurring during the course of his employment and growing out of it, just as much as anyone else.

His injuries can largely be attributed to the familiar non-mechanical causes of: Handling materials, hand tools, striking against objects, burns, electric shock, flying objects striking the eyes, and the general mechanical hand and tool injuries due to handling machines while in motion, or inflicted by machines put in motion by others while under repair.

The safety activities of these maintenance workers will be discussed here in connection with some of the more important jobs and the incidental danger, together with the safety measures and other precautions which may be taken in the protection of themselves, the operators, other workers and the equipment. For example, the electrical workers have many hazards incidental to their work which they can guard against by carefulness and by the many improvements in switches and other protective equipment. A big hazard results from the possibility of unsafe actions of others. This must be guarded against as well.

Perhaps the first rule of all electrical workers, or any other worker who may be called upon to fix or adjust a machine, is to disconnect by switch or otherwise the machine or power circuit worked on. Even then, the danger of another throwing in the circuit or starting the machine is so great that the frequently used "Danger" or "Man Working on Machine" sign can hardly be relied upon. In spite of rules against the unauthorized removal of such signs, many accidents are the result of such acts. The only safe and secure way is for each worker to close by his own padlock, the switchbox or other disconnecting devices so that no one else can tamper with them. Such a case is shown in the illustration at the head of this article where four men repairing a machine had each placed his lock on the switch box after disconnecting the power. Other illustrations show different applications of lock equipment. It should be unnecessary to caution against using cheap padlocks which are easily unlocked by many different keys.

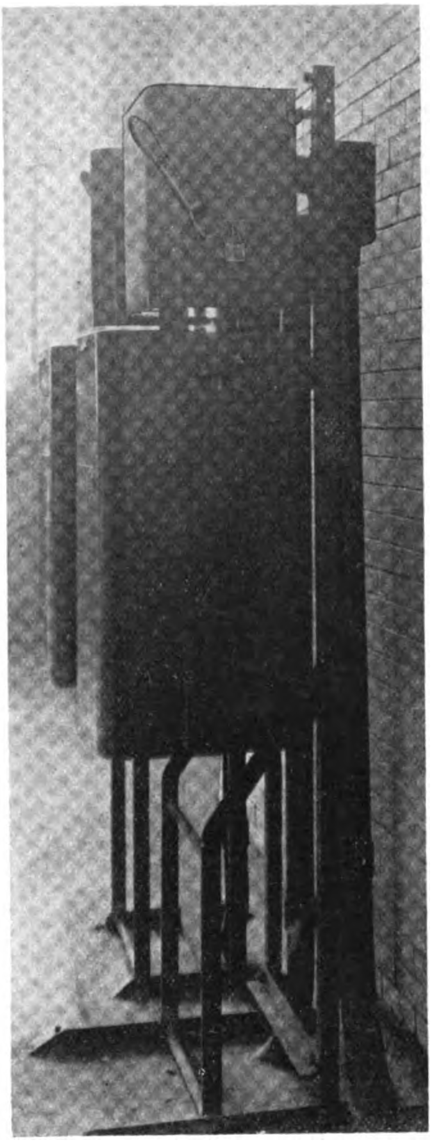
The objection is sometimes raised that the men may neglect to remove their padlocks and so tie up a ma-

The fourth man on the job inserts his red safety lock before starting. Even though three locks are already on this switch box, this does not make it safe for the fourth worker as the other three men may complete their part of the work and remove their locks before he is through. This shows in detail the switch box on the charging car, also shown at the heading of this article. These two, and several other pictures in this group were taken at the South Works of the Illinois Steel Co. and at other plants of the United States Steel Corporation.

chine longer than necessary. This, however, is a matter of supervision and probably would never occur more than once. At any rate, the result would never be as serious as it might be if a "Danger" sign were removed or accidentally fell off.

Ladders are responsible for many of the injuries to maintenance workers. These are due to slipping, to reaching too far instead of moving the ladder, and to the use of poorly constructed, broken, or patched up collections of sticks loosely nailed together which hardly deserve being called a ladder. It is surprising how many of this last type are still in use. Slipping may be prevented by non-slip footings on ladders or, when possible, by hooks at the top of the ladder which may be caught over some overhead object, such as a lineshaft. Prongs are commonly used on the foot of ladders as non-slip devices but cannot be relied upon for concrete or hard flooring. Also, men have injured their feet when forcing the point down to "set" it in the flooring.

Instead of using portable hand ladders to get at motors and other equipment mounted overhead, it is usually best to build permanent ladders, as they absolutely eliminate the ladder-slipping hazards and are always on hand for emergency inspections or other attention. Where considerable overhead work is to be done, it pays to build a portable platform. Some shops have such platforms of a convenient height for lineshaft or other overhead work placed permanently in each department. Any inspection routine should include a careful examination of all ladders and platforms. To be sure that all ladders are inspected each time, it is well to identify each with a tag or painted number and see that all are accounted for. It would be well, too, to have some provision for condemning those which are not and cannot be made safe. Instead of painting, it is also better to oil or shellac ladders and leave them in the natural wood so that any crack or split will be visible at once.



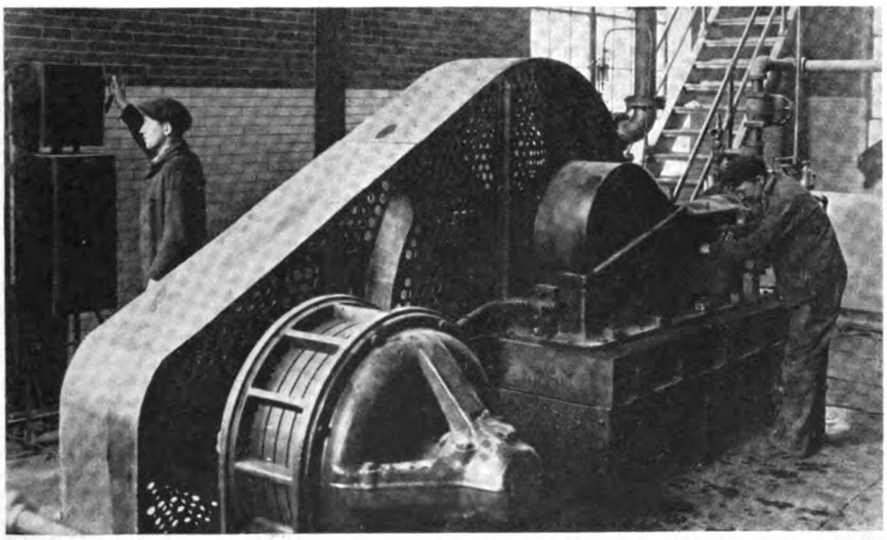
The compensator for the motor which drives the air compressor in the accompanying illustration was locked in this manner.

Staples are attached to the moving parts of the compensator handle and also to the box. When the power is thrown off and the lock inserted no one can move the handle without the key. As the workman alone carries this, he is safe at his work.

While shafting offers the greatest danger to oilers, other workers are injured by contact with it. For example, during the past twelve months, two painters have been whirled to death on shafting. The accident report read, "While stooping to put brush in pail, loose jumper wound around shaft." As the shafting was located about 3 ft. below a 20-ft. ceiling, no one anticipated the possibility of that accident. Perhaps those human sacrifices will save others, for now the painters are required to hang a board between them and the nearby shafting while they are working on ceilings and upper walls. This safeguard is simple since the need of it has been pointed out and consists of one board, two strings and two nails. The nails stay in place and are ready every time the maintenance program brings the painters back. The board is moved along as the position of the scaffolding is changed.

This kind of accident also points out another hazard to maintenance workers. Loose clothing, rings and loose neckties are likely at any time to get caught on moving machinery and draw the worker into it. The danger is somewhat greater to maintenance men in that their work requires close proximity to moving parts of many machines with which they are often not familiar. No other employe is ever called upon to put his arms and hands so near pulleys, gears, belts and shafts as is the maintenance man. Very frequently his familiarity with this work breeds a contempt and disregard for the danger. The prevention of the wearing of loose clothing is a matter of supervision and education of the worker to the hazards involved.

That division of maintenance work



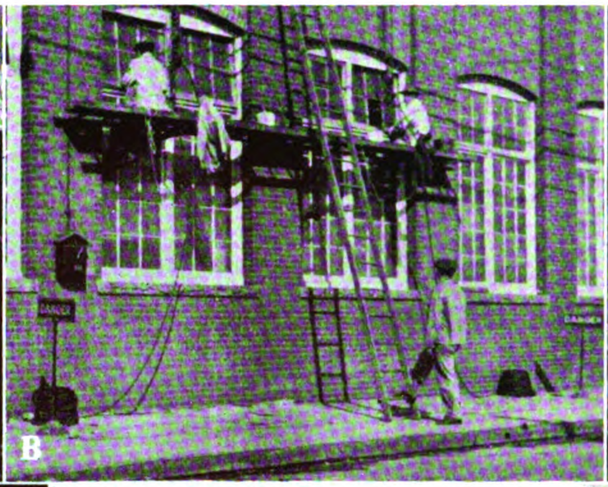
The repairman works on this air compressor without fear, and in safety.

Before he started on this job, this repairman locked the compensator. Therefore, he does not have to keep one eye on it while doing his work, to prevent anyone coming along and starting up. This illustration shows one of the other workers trying it, but unsuccessfully. The method of locking the compensator is shown in another illustration on this page.

Some Safeguards for Maintenance Workers

Eleven Devices Which Protect Operators as Well as Repairmen


A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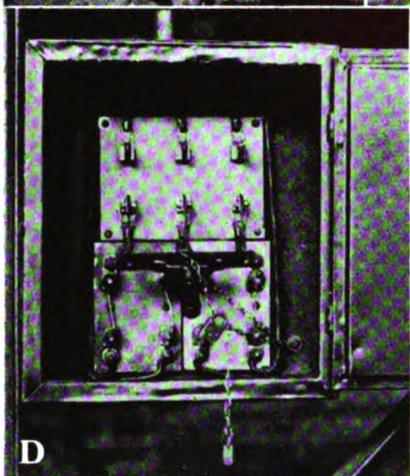
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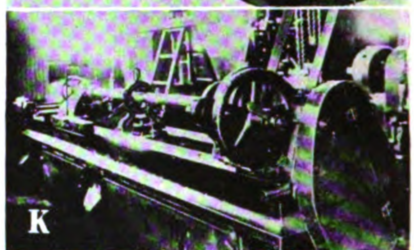
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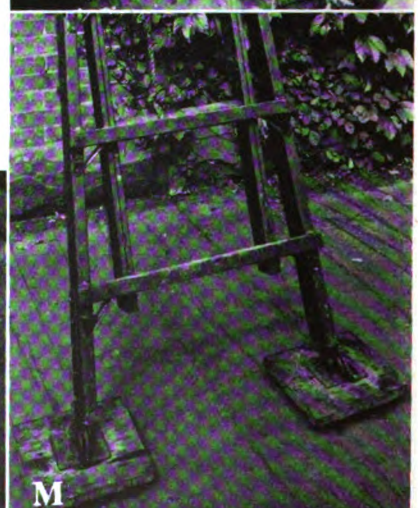

M

A—With the steam valve locked, workmen feel more safe in entering boilers.

B—In addition to other safeguards, the passerby is warned of men overhead by danger signs.

C—The blowoff valves are removed while men are working within the boiler to prevent steam from backing up in case another boiler is blown off.

D—One method of locking a knife switch open while making repairs.

E—Guards placed on a lineshaft and coupling located near the floor.

F—Loose clothing caught on this shaft and a man was killed. Bearings which require less frequent oiling decrease the insurance premium rate.

G—Although this man has lost one finger, he is taking a chance on "just a little job" and not setting the guard first.

H and I—Another type of locking device for valves which prevent their being accidentally turned on.

J—This sheet metal guard and danger sign is locked over the handle of the valve to prevent it being turned on too soon.

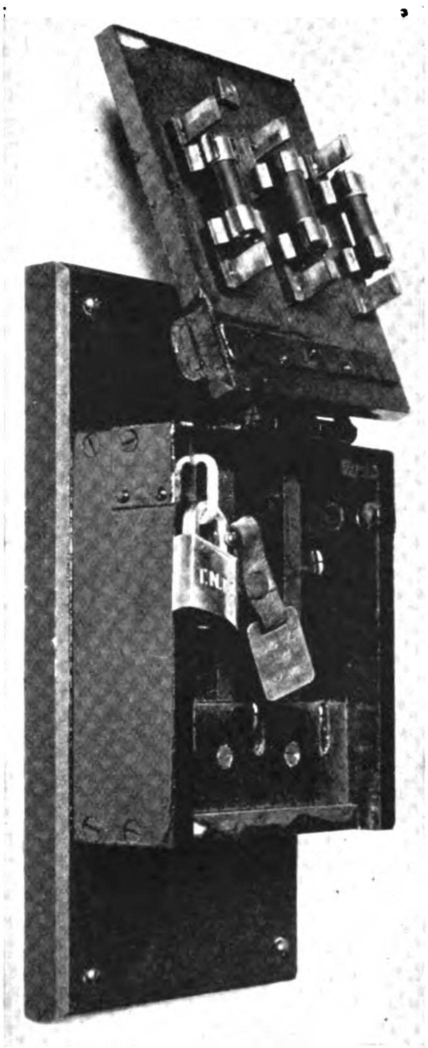
K and L—These show an effective sheet metal guard on lathe gears which may be opened for inspection, changing or oiling.

M—Here the legs of the ladder are supported on special non-skid footings covered with cocoa matting. Cork, rubber and abrasives are also used frequently. Note also the bracing of the rungs.

connected with the erection and dismantling of machinery and equipment has in addition to the ladder hazard, a hazard of falling material. All chains, blocks, falls and ropes used should be inspected frequently and discarded when they show any signs of excessive wear. Here is another place where the education of the maintenance worker toward exercising extra care and in a knowledge of the loads and stresses involved in lifting heavy weights, is important. Not only are the men in danger, but in addition there is always a possibility of damage to the machinery handled.

Leaving bolts, tools and loose pieces overhead to fall down later due to the vibration of the building can best be prevented by supervision and education of the men. The common practice of carrying an armful of tools up a ladder or tossing them up should be discouraged and the better method of pulling them up with a rope substituted. When men are working overhead, the space beneath should be fenced off or at least protected by signs reading, "Men Working Overhead," or some similar sign to prevent injury to the passing fellow employe.

Unless the maintenance worker appreciates the value of safeguards on machines, it is often difficult to get the men to use them on the saws and other machine tools in their own small shop. The same is true of goggles employed when using grinding wheels or chipping metal. Fre-



Another arrangement whereby the power circuit can be locked open.
Here a check is attached to the padlock, showing the department and number of the man who has locked the switch open. In this way, it is easy to check up and find why and by whom the disconnect was made.

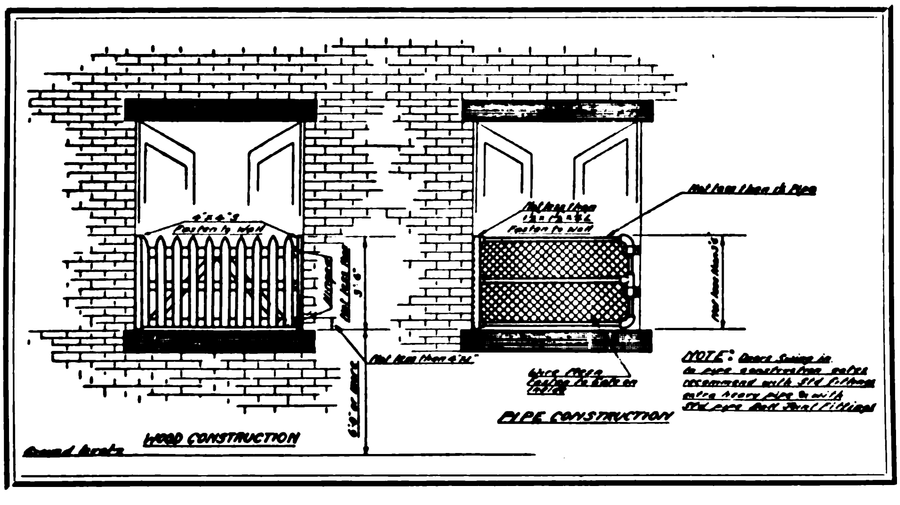
quently, this work occupies such a small amount of time and is so special as to require the resetting of the guard that the men do not think it necessary. Besides, they often feel that they are a little more sure than are the other workers. Mushroom tools offer another hazard which can be prevented by adequate inspection.

In his work a maintenance man comes in contact with every hazard incidental to the operation of any department in the plant. For example, with the increase in the use of ammonia, chlorine, hydrogen sulphide and other gases, entirely new hazards are presented to these workers. All workers who may at any time be called upon to do any repair work where they may be exposed to escaping gases should have experience in the use of a gas helmet and a life belt.

Perhaps due to his versatility in being required to repair almost everything, the maintenance worker and the management thinks he knows how to take care of himself and to some extent have overlooked his safety. Rather, however, greater care should be exercised in training him and preparing him to take the precautions necessary for his safety, as he is constantly exposed to new, unexpected and unusual conditions to a far greater extent than are the workers in any other occupation.

An article in a later issue will take up standardized safeguards, inspection methods and organization of safety work with special reference to the part taken in this by the maintenance organization.

These standard types of guards for wall openings have been approved by the insurance companies.
In the construction of safeguards in industrial plants great emphasis is placed on the use of standard forms of guards, approved by the insurance companies. This sketch shows a type of guard approved by the American Mutual Liability Insurance Company of Boston. This is a standard guard for wall openings and may be of either wood or pipe construction.



Works of Shredded Wheat Company

(Continued from page 311)

on an endless chain. Each biscuit is built up of thirty-six layers of separate shreds. A special cutting machine forms this long band of shredded filament into oblong cakes and deposits them on a pan holding fifty-two biscuits. Each pan of biscuits passes through two separate ovens which bake and crisp them. Next, the biscuits are taken to the packing rooms where they are placed in cartons which are carried on a conveyor to a special sealing machine which also dries the vegetable glue used in sealing the cartons.

Two interesting problems of this industry result from the care required in handling because of the fragile nature of the product and also from the increase in bulk of the packed biscuits over the original bulk of the wheat. While this packed and finished product is not heavy, it nevertheless requires large storage area and care in handling.

Details and Diagrams For Making a

Special Chorded Split-Pitch Loop Winding

For Use on Small Motors Together With Complete Information on How to Wind in the Coils And Make the Connections to the Commutator With the Reasons Why and the Advantages Obtained by the Use of Such a Winding

A SPLIT-PITCH winding is one in which each two coils are wound in three slots, the two coils each having a different pitch. In the winding on the motor described in this article, the first coil has a pitch of 1 and 11; the second coil has a pitch of 1 and 10; the third coil has a pitch of 1 and 11; the fourth coil a pitch of 1 and 10, and so on. In this article Mr. Roe tells why and where such a winding is used and the precautions to take when making it.

By A. C. ROE
Repair Superintendent, Detroit Service Dept., Westinghouse Electric & Manufacturing Co.

MANY small, two-pole motors having an armature with a large number of slots and small end-room are wound with a special chorded, split-pitch winding. This winding can be used with any number of slots where there are two or four times as many bars as slots.

This type of winding was used on a 5-hp., 1,110-r.p.m., two-pole motor that recently passed through our shop. The diameter of the armature was 10 in.; it had twenty-four slots and forty-eight commutator bars.

If full pitch, 1-and-13, had been used, the winding would have piled up on the ends of the armature and taken up too much space. This would have been caused by the end turns having to cross the maximum number of coils and also bend around the shaft, since slots *1* and *13* are on diametrically opposite sides of the shaft.

To eliminate some of the coil crossings and to prevent the coil ends from bending around the shaft, the coil pitch was reduced to 80 per cent of full pitch. Full pitch equals 12 on this armature; hence 80 per cent of full pitch would equal 0.80×12, which equals 9.6. This is equivalent to using slots 1 and 10.6. Since 0.6 of a slot cannot be obtained, it was decided to use a split-pitch winding; that is, to wind one coil with a pitch of 10, as 1-and-11, and to wind the next coil with a pitch of 9, as 1-and 10. This gave an average pitch of 9.5, which approximates the desired pitch of 9.6.

This particular winding had odd turns; that is, one coil had seven turns and the second had eight turns. The long pitch, 1-and-11, coil had eight turns, while the short pitch, 1-and-10, coil had seven turns.

Armature Is Wound With One Wire in Hand

This type of winding must be wound with one wire in hand, regardless of the number of times the commutator bars exceed the slots.

In winding the armature, it should be placed with the commutator on the left-hand side of the winder, as shown in Fig. 1. In this diagram the start of the winding is shown at S_1. The winding can be started from any slot and the slot from which it is started is called slot *1*. The S_1 lead is left long enough to reach to the proper commutator bar, and a white sleeve is put around the lead. The wire is bent down from the front or commutator end of slot *1* and carried across to slot *11*, through slot *11* up the back of the armature to slot *1*, and through slot *1* as shown by the arrows in Fig. 1. Eight turns are wound in slots *1* and *11*. F_1 is the finishing end of the first coil. A loop is then made of the finishing end, F_1, of the first coil and the starting end, S_2, of the second coil. This loop should be long enough to reach to the proper commutator segment and a red sleeve is put on it. The starting end, S_2, of the second coil is carried down the front of the armature to slot *10*, through slot *10*, up the back of the armature to slot *1*, and through slot *1*, as indicated by the arrows in Fig. 1. Seven turns are wound in the second coil. Fig. 2 shows the front end of the armature with the first four coils wound in. In this figure S_1, F_1, etc., refer to the starting and finishing ends of the respective coils, the same as in Fig. 1. The small circles in the slots represent the different coils and the number in the circles indicates the coil number and the order in which the coil is wound. The commutator loops made up of the starting and finishing coil ends, F_1, S_2, S_3, etc., are also shown in the diagram.

At this stage of the winding, slot

Fig. 1—Side view of the beginning of a split-pitch, loop winding.
S_1 is the start and F_1 is the finish of the first coil. This coil consists of eight turns wound in slots *1* and *11*, as indicated by the arrows. At the finish of the first coil a loop is made long enough to reach the proper commutator bar and at the end of this loop the second coil is started at S_2, in slot *10*. The second coil is wound in slots *1* and *10* as indicated by the arrows. An end view of the first four coils is shown in Fig. 2.

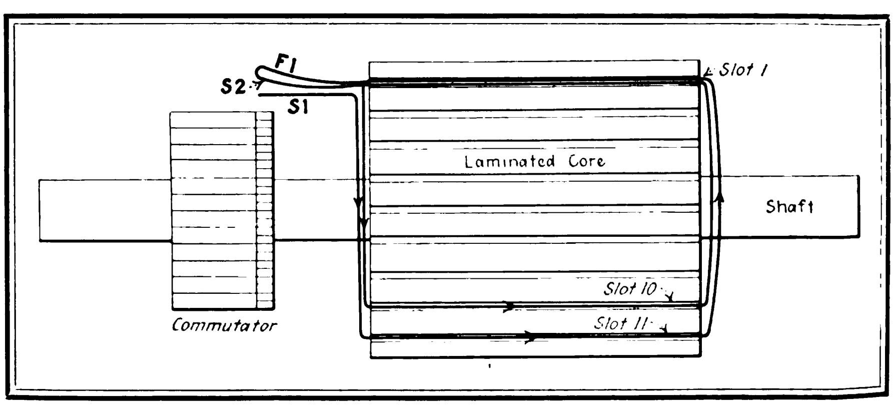
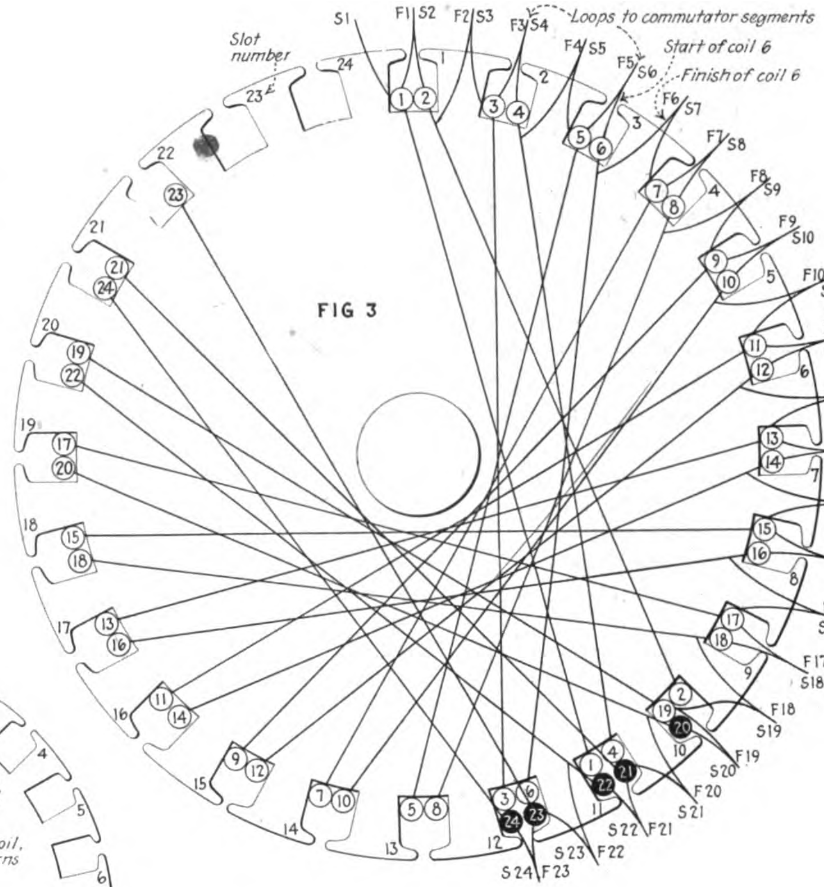


Fig. 2—End view of the winding shown in Fig. 1.
The coil starts at S_1 and consists of eight turns wound in slots *1* and *11*, as shown by the bunch of wires marked *1* in the two slots. A loop is made of the finish of the first coil, F_1, and the start of the second, S_2, which is to be connected to the proper commutator bar. A red sleeve is put over this loop. Beginning with S_2 and ending with F_2, the second coil is wound with seven turns in slots *1* and *10*. At F_1 a loop is made long enough to reach to the proper commutator segment and the third coil is begun at S_3. A white sleeve is put over the loop made by F_2 and S_3. The third coil consists of eight turns wound in slots *2* and *12*.



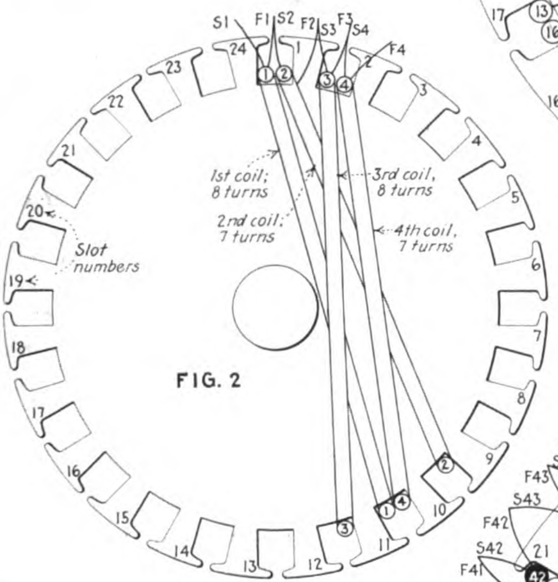


Fig. 3—This diagram shows the armature with the first half of the coils in place.
Note that the top layer of coils begins in slot *10* with coil *20*. The upper layer coils in each slot are indicated by black circles with white letters. The letters *S* and *F* indicate the starting and finishing leads of each coil. The numbers in the circles indicate the coil number and the order in which the coil is wound on.

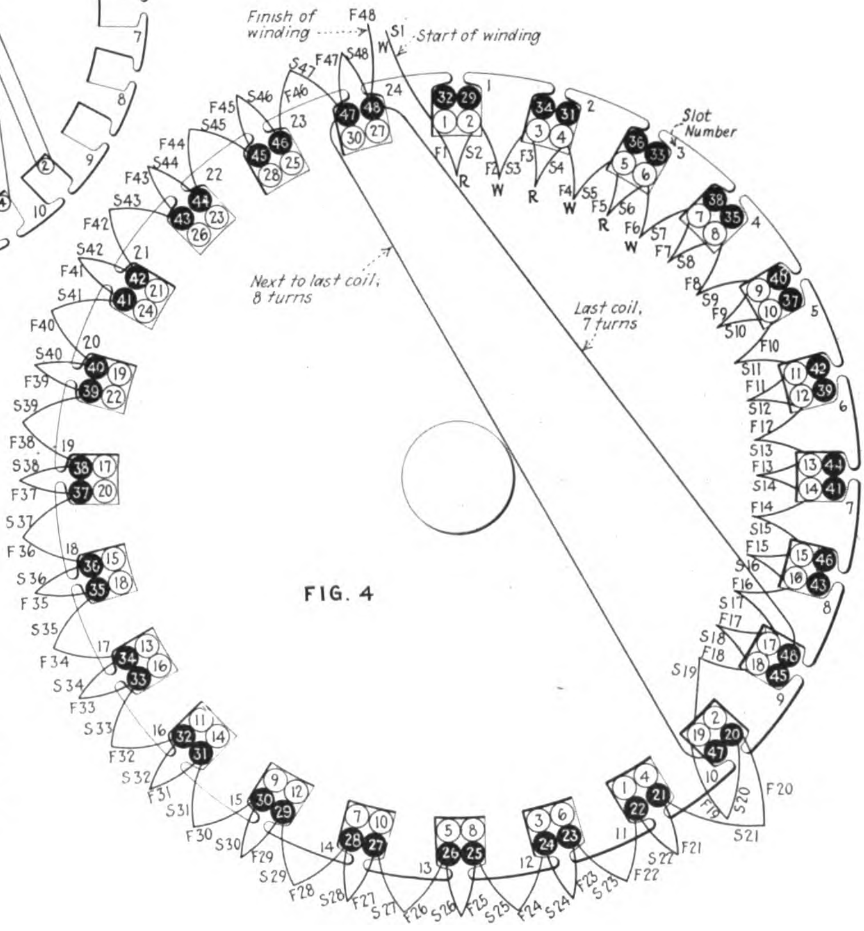


Fig. 4—All of the coils have been wound in the slots, in this diagram.
The last two coils have been drawn in to show how the winding ends. F_{48} and S_1 are joined together and treated as a loop to be connected to the last commutator bar. The letters *R* and *W* indicate the color of sleeving used for each loop.

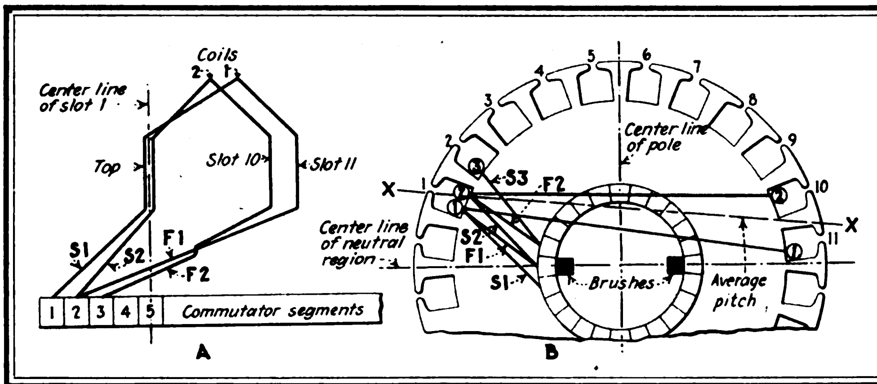


Fig. 5—The connections of the loops to the commutator is shown in these two diagrams.

In *A*, it will be seen that the loop connections to the commutator are given a forward lead. This is to compensate for the chorded pitch. In *B*, coil *2* is shown in position for commutation. The line *XX* indicates the average pitch.

1 will contain two halves of a coil, slot *10* one-half, and slot *11* the other half. With the end F_2 of coil *2* and the start, S_3, of coil *3*, a loop is made on which is put a white sleeve. Coil *3* is wound by running the wire from the loop across the front of the armature to slot *12*, through slot *12* and up the back of the armature to slot *2* and through slot *2*. Eight turns are wound in this coil through slots *2* and *12*. At the finish F_3 of coil *3* a loop is made and a red sleeve is put on it. The fourth coil is wound with seven turns in a manner similar to the previous coils, in slots *2* and *11*. There are now four coils in five slots, as is shown in Fig. 2.

Use of Colored Sleeves to Mark Commutator Loops

The above procedure is followed through until the forty-eight coils are in place, remembering to use eight and seven turns alternately and putting white and red sleeves on alternate loops. Fig. 3 shows the first twenty-four coils in place. Notice that coil *20* starts the upper layer of coils in slot *10*. In Fig. 3 the numbering system is the same as in preceding diagrams. Fig. 4 shows all the coils laid in the slots and also shows all the loops to the commutator; *R* and *W*, indicating red and white sleeves, are marked beside the first few loops to indicate the sequence of the sleeves. The last two coils are drawn complete so as to show how they are wound in. The end, F_{48} of coil *48* is connected to the start S_1 of coil *1* to make the final loop. In this and the preceding diagram, the black circles with white numbers indicate the coils wound in the upper layer of the slots.

Method of Connecting Loops to Commutator

In *A* of Fig. 5 is shown the commutator connections. The brushes are on the center line of the neutral region as shown in diagram *B* of Fig. 5. Hence the leads are given a forward lead to compensate for the chorded pitch. As will be seen from diagram *A*, the loop made up of S_2 and F_1, is connected three bars ahead of the bar in line with slot *1* in which are the top halves of coils *1* and *2*. The other loops are connected in a corresponding manner. When connecting the loops to the commutator, first connect a white sleeve, followed by a red sleeve, and follow alternately with a white and a red sleeve until all are connected. Or the loops can be connected in two layers. First connect all the white-sleeved loops leaving a bar between each loop. Then put a band of tape over these loops, after which the red-sleeved loops may be connected in order to the remaining bars.

The most important precaution when connecting this type of winding is to get the lead throw correct, as connecting it one or two bars off will considerably shorten the life of the winding. This is due to the fact that when the leads do not have the right throw, one part of the coil will be in an active field, which will generate a current opposing commutation. This will cause the coils to heat and in time roast the winding.

Brakes for Stopping Rotating Parts

(Continued from page 320)

shoe or disc clearance is so great and likewise the air gap of the operating magnet has become so large that the magnet is unable to pull the brakes open. This can be remedied by decreasing the clearance between the shoes and the wheel; this in turn decreases the air gap of the magnet and permits it to exert a greater pull to release the brake. On solenoid-operated brakes, excessive shoe clearance causes the core of the solenoid to fall too far through the coil, thus decreasing its pull. The remedy is to decrease the excessive clearance between the shoes and the brake wheel, the same as in the case of the magnet-operated brake.

Occasionally the operating coil grounds or shorts, either due to vibration or to imposing too heavy duty on the coil. It is obvious that a half-hour rated coil for crane service cannot be expected to stand up under 60-min. mill service. The remedy is obvious. Coils may be easily removed and repaired or replaced with new ones.

The linings on the shoes, bands, or discs must be watched and replaced before they are worn through. If the lining is permitted to wear through, grooving of the brake wheel is likely to result and thus decrease braking torque.

Brake wheels will wear in time. If they become grooved they may be taken off and trued up in a lathe. Care should be taken that too much material is not taken off, otherwise the wheel will lose much of its strength and will be liable to break while in service. Brakewheels should be replaced when they become worn to the point where they are unsafe. To have a brake wheel explode in an industrial works may be very disastrous. Men may be killed or injured and machinery damaged by the flying pieces. Only careful inspection and maintenance can prevent disastrous occurrences of this kind.

Editor's Note: Special acknowledgment is made to the following companies for assistance in furnishing information, data and illustrations for this article: Allis-Chalmers Mfg. Co., Milwaukee, Wis.; E. C. Atkins & Co., Indianapolis, Ind.; Commercial Chemical Co., Boston, Mass.; Cutler-Hammer Mfg. Co., Milwaukee, Wis.; Electric Controller & Mfg. Co., Cleveland, Ohio; General Electric Co., Schenectady, N. Y.; Kelso Mfg. Co., Trenton, N. J.; Sundh Electric Co., Inc., Newark, N. J.; Thermoid Rubber Co., Trenton, N. J.; Tool Steel Gear and Pinion Co., Cincinnati, Ohio; Westinghouse Electric and Mfg. Co., East Pittsburgh, Pa.

In compiling this article information has been obtained from a chapter on electric brakes in a new book, "Principles of Electric Motors and Control," by Gordon Fox, published by the McGraw-Hill Book Co., and also from an excellent paper, "Auxiliary Electrical Equipment for Motor-Operated Cranes," presented before the A. I. E. E. in 1922 by H. W. Eastwood.

This photograph was taken in the Harrisburg (Pa.) Silk Mill. The lighting system uses one Holophane No. 621 intensive type reflector with a 200-watt lamp hung over the center line of the fronts of each two looms. The spilled light from these units is considered adequate for the illumination of the backs of the looms. The intensity in the front of the looms is 30 foot-candles and at the back of the looms 12 foot-candles. The cost of this installation was one-half cent per foot-candle per square foot.

Details of a Method for Using

Unit Costs in Installing Systems of Lighting

To Obtain a Quick Estimate of Costs When the Area to Be Lighted, Foot-Candles of Intensity and Type of Equipment to Be Used Are Known

By DAVIS H. TUCK
Electrical Engineer, Holophane Glass Co., New York, N. Y.

THIS ARTICLE was presented by Mr. Tuck before the last annual convention of the Illuminating Engineering Society as a guide in the preparation of estimates on the cost of lighting required for different industrial operations. It shows how to secure lighting equipment and layouts that not only provide the necessary lighting intensity but have low unit cost of installation. The unit-cost basis in cents per foot-candle per square foot of floor space in estimating both installation and operating expenses is of practical value to both the man who is to pay for the installation and the man who works up the estimate as an installation job. In many cases a study of unit-cost figures of installation and of operation will make it possible to secure the lowest possible expenditure for both items without sacrificing the quality of lighting provided.

IN THE PAST, industrial lighting cost figures have been based on one 100-watt outlet or on a complete installation in one department. Such figures are of little practical value, inasmuch as they have no common basis. Also, such cost figures as have been used in the past, have no direct bearing on the amount of illumination that is received for the money paid out. Thus, when it is stated that the total annual cost of eight 400-watt lighting units is \$340.00, this \$340.00 has no practical significance, until it is reduced to some unit cost, and unless additional data are given, such as the type of reflector equipment, the floor area to be illuminated, and such other data as will determine the utilization coefficient, this common basis cannot be arrived at. When it is remembered that it is foot-candles at the work, and not watts at the socket, that are bought and paid for, it is seen that the unit cost of lighting should be based on foot-candles at the work.

In the case of the lighting installation already referred to, where eight 400-watt lighting units cost \$340.00 per year, it was found that a uniform illumination of ten foot-candles was obtained over an area of 3,200 square feet. It would follow that the logical unit cost would be \$340.00 ÷ (10 x 3200) = one cent per foot-candle for each square foot. This is equivalent to saying that one effective lumen per square foot costs one cent for this particular installation.

The cost in cents per foot-candle per square foot is the logical unit cost for industrial lighting and has already been used effectively in practical application. In one instance, a silk factory in Virginia wired an elec-

trical contractor in New York City for a price on re-lighting their *Weave Department.* The contractor answered by wire that it would cost one half of a cent per foot-candle per square foot of floor area and received a wire to proceed with the work.

The unit cost of lighting expressed in cents per foot-candle per square foot can be divided into two parts: (1) Unit installation cost and (2) unit operating cost.

Unit Installation Cost

The unit cost of installation in cents per foot-candle per square foot is of practical value and interest both to the electrical contractor and the owner. The contractor who has kept unit cost figures in cents per foot-candle per square foot soon arrives at unit-cost figures which will apply to various types of industrial installations and can devise methods of lighting which will lower these unit-cost figures. Thus, if a contractor has installed several lighting installations in *Weaving Departments* of silk mills and finds that the unit installation cost in cents per foot-candle per square foot is one cent when one type of installation is made and that by using careful design this unit installation cost may be cut to one-half of a cent, he is evidently at an advantage as regards competition.

The unit cost of installation is arrived at in the following way:

Cost of reflector equipment (consumers discount) ....\$........
Cost of lamps on (consumers discount basis) ....
Cost of wiring (to consumer) ....
Incidentals (certificate, extras, etc.) ....

Total cost of complete job (Contractor's bill) = C..\$........

Calculated illumination intensity checked after installation with a portable illuminometer = E

Total number of square feet of floor area served by the lighting equipment = A

Then the unit cost in cents per foot-candle per sq. ft. = $(C \times 100) \div (E \times A)$.

To the owner, the unit installation cost of lighting in cents per foot-candle per square foot is a logical and convenient figure. If the owner has made a definite appropriation for the installation of lighting equipment, all he has to do is to divide this appropriation by the number of square feet to be illuminated and by the unit cost of installation and the result will be the illumination received on the work in foot-candles.

Table I—Unit Cost of Installation in Cents Per Foot-Candle Per Square Foot for Various Types of Industrial Lighting Installations

Industry	Type of Reflector	Area per Sq. Ft.	Average Foot-Candles	Unit Cost Cents per Foot Candle per Square Foot
1. Wool Yarn Mule Spinning	Hol. No. 621	12,000	30	0.48
2. Metal Stamping	RLM	5,424	3.5	2.95
3. Elec. Mfg. Assembly small parts	RLM	6,860	11	1.78
4. Wool Weaving	Porcelain Enam. Shallow Dome	4,888	11.9	2.45
5. Knit Goods. Knitting Mach.	RLM	3,200	5.6	1.23
6. Soap Mfg. General	RLM	7,974	2.5	2.68
7. Struc. Steel. General	Porc. Deep Bowl	208,380	2	0.66
8. Auto Mfg. Paint Shops	Deep Bowl Steel Enam.	48,000	3.5	1.01
9. R. R. Repair Shops	Deep Bowl Steel Enam.	3,264	1.7	0.52
10. Aluminum Spinning	RLM	29,680	3.6	1.25
11. Office Coal Company	Filterlite Enclosing Glass	5,500	3.0	5.14
12. Silk Weaving	Hol. No. 621	12,000	30	0.50

On the other hand, if the owner knows the unit installation cost of the lighting to be done and the intensity of illumination required, the installation cost can be arrived at by the simple relation shown above.

The unit cost of installation has been kept for several types of lighting installations, several of which are shown in Table I.

The unit installation cost for direct lighting of the RLM industrial type is indicated in Table I as roughly two cents, and that of semi-indirect lighting characteristic of a high-class, totally-enclosing globe type indirect 69 per cent, direct 31 per cent (Item 11) is 5 cents.

Item 9 has a low unit cost, 0.52 of a cent per foot-candle per square foot, because 750-watt lamps were used, thereby lowering the installation cost and the cost of the reflectors.

The low unit installation cost of Items 1 and 12 are due to the method of installation. In both these cases the localized general type of installation was employed and due to the intensive type of light distribution, a high illumination intensity on the looms was received at the expense of the aisle illumination. It is to be noted that in such cases where

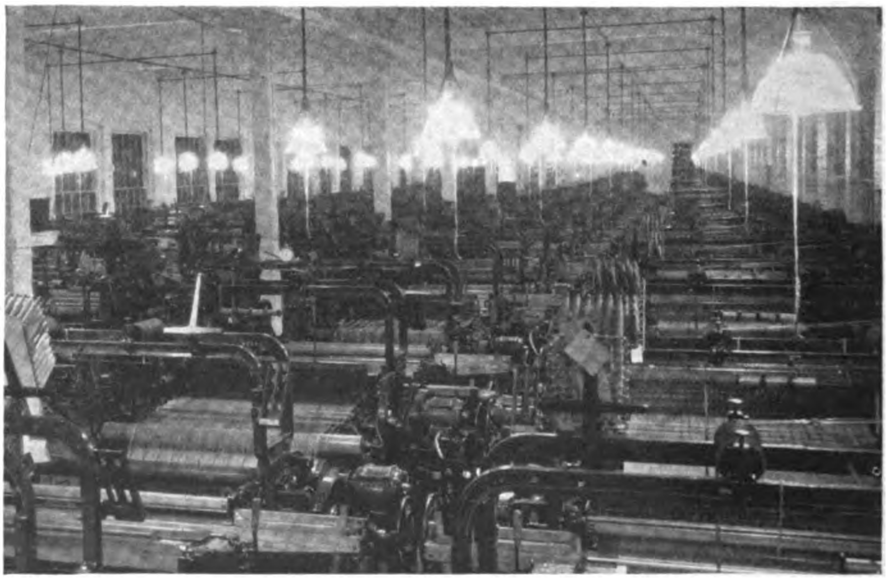


Fig. 1—Localized general lighting in the Arohnson Silk Weaving Mill, at Coatesville, Pa.
This installation uses one Holophane No. 621 intensive type reflector with a 200-watt lamp placed over the center line of the fronts of each two looms. One Holophane No. 622 intensive reflector with a 200-watt lamp is placed over the center line of the backs of each four looms. There are 150 watts for each loom with this arrangement. The intensity at the front of the looms is 25 foot-candles and at the back of the looms 15 foot-candles. The cost of this localized general lighting was seven-tenths cents per foot-candle per square foot.

the illumination is not uniform over the entire floor area unit cost expressed in cents per foot-candle per square foot is in a way a misnomer, inasmuch as the foot-candles times the square feet of floor area do not give the total useful lumens. When interpreting unit costs of lighting for non-uniform systems, the nature of the work must be taken into account.

Thus, in the case of Wool Yarn Mule Spinning, the working plane is limited to the strip of shaded area (see Figure 2). If, therefore, the light from the lamps can be concentrated on this strip of working plane and gradually shaded off in the aisles, the apparent coefficient of utilization can be increased and the unit cost installation lowered.

We have become accustomed to speak of useful lumens, as those lumens which were delivered to an imaginary horizontal plane about 30 inches above the floor and the efficiency of utilization is taken as the ratio of these useful lumens to the total generated lumens. It is entirely possible, however, to have some useful lumens that are more useful than other useful lumens. For instance, in Fig. 2, the lumens in excess of 3 per square foot in the aisles and non-shaded portion are not as useful as those in excess of 3 in the shaded portion.

How this idea of some lumens being more useful than others works out in practice toward lowering the unit cost of installation, is seen by the following example.

It is desired to illuminate the mules previously referred to, (an actual installation) to an intensity of 30 foot-candles. The floor area occupied by the spinning department is 12,000 square feet; when the uniform system of illumination was used, the unit cost based on RLM reflectors and 200-watt lamps was 0.88 of a cent per foot-candle per square foot. When the localized general system of illumination is employed where it is recognized that the lumens on the work are more useful than lumens in the aisles, the unit cost of installation was only 0.48 of a cent per foot-candle per square foot.

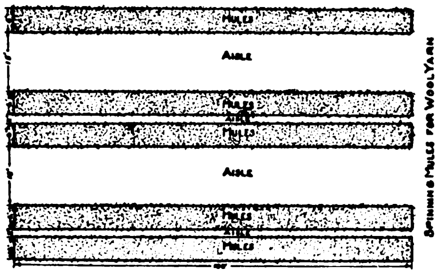


Fig. 2—A floor plan of a part of a mule spinning room in a wool yarn factory.

Unit Cost of Operation

The unit cost of operation in cents per foot-candle per square foot is of more interest to the owner than to the electrical contractor. In the same way that the owner really buys the installation of a definite number of foot-candles of illumination, he also pays for the operation of a system that will maintain a definite number of foot-candles on the working plane.

The unit cost of operation is arrived at as follows:

Six per cent on total cost of installation (contractor's bill)	.$......
Percentage depreciation on equipment (contractor's bill less lamps)	......
Lamp renewals based on 1,000 burning hours as the life of the lamp	......
Cost of current	......
Cost of cleaning	......
Incidentals	......
Total operating cost, C	...$......

Actual average intensity in foot-candles as read before and after cleaning intervals $= E$.

Total number of square feet of floor area served by the lighting equipment $= A$.

Then the unit cost of operation in cents per foot-candle per sq. ft. $= (C \times 100) \div (E \times A)$.

The unit cost of operation has been kept for the same installations as shown in Table I. Table II shows the unit cost of operation of these several typical installations.

Table II indicates that the unit cost of operation for direct illumination of the RLM type is roughly 1.3 cents per foot-candle per square foot and that the unit cost of semi-indirect (indirect 63—direct 31) lighting of a high-class totally enclosing globe is roughly 2.3 cents per foot-candle per square foot. It will be noted that the unit cost for the RLM installation varies from 1.0 to 1.6 and this difference is due to the way in which the installation was planned and the degree of depreciation that had set in at the time of the illumination test.

The low unit cost of operation for items 1 and 12 are due to the method of installation as had already been pointed out under unit cost of maintenance. It is here that the great benefit to be obtained by a properly planned system of localized general illumination is realized, for, whereas the low unit cost of installation for such a system is evident, this cost is not of as great importance as the unit cost of operation, inasmuch as the latter must be met every day, and such a saving is cumulative.

Upon an examination of the formulas for the unit cost of installation, it is evident that in order to lower this unit cost, the foot-candles of illumination must be increased or the cost of the equipment must be decreased or both. Inasmuch as the cost of lamps and labor of wiring and hanging the reflector equipment are stable quantities, the reflector equipment is the only item where a

Table II—Unit Cost of Operation in Cents Per Foot-Candle Per Square Foot for Various Types of Industrial Lighting Installations

Industry	Type of Reflector	Area	Average Foot-Candles	Unit Cost Cents per Foot Candle per Square Foot
1. Wool Yarn Mule Spinning	Hol. No. 621	12,000	30	0.36
2. Metal Stamping	RLM	5,424	3.5	1.60
3. Elec. Mfg. Assembly small parts	RLM	6,860	11	1.20
4. Wool Weaving	Shallow Dome Porcelain Enam.	4,888	11.0	1.60
5. Knit Goods—Knitting Mach.	RLM	3,200	5.6	1.01
6. Soap Mfg. General	RLM	7,974	2.5	1.63
7. Structural Steel. General	Porcelain Enam. Deep Bowl	208,380	2	1.3
8. Auto Paint Shop	Porcelain Enam. Deep Bowl	3,264	3.5	0.98
9. R. R. Repair Shop	Porcelain Enam. Deep Bowl	48,000	1.7	1.47
10. Aluminum Spinning	RLM	29,680	3.6	1.26
11. Office Coal Company	Filterlite Encl. Glass 69-31	5,500	3.0	2.3
12. Silk Weaving	Hol. No. 621	12,000	30	0.45

saving can be made. It is entirely possible, however, to increase this reflector factor of Item *C* and reduce the unit cost of the illumination by using more effective reflector equipment. An example of this method of reducing the unit cost of installation is shown in Items 1 and 12 of Table I. The unit cost can also be reduced by using a few large units in place of many smaller units. This latter reduction in unit cost, however, is ordinarily made by sacrificing the quality of the light. In some instances, however, in such locations as an armory, power plant, foundry, gymnasium and industrial plants where the locations of crane-ways make it necessary to mount the luminaires relatively high (25 feet or more above the floor), it is possible to reduce the unit cost of installation greatly, without sacrificing quality of illumination, by the installation of large lamps in reflectors of the intensive type. By using reflector equipment having a well pronounced intensive type of distribution hung high it is possible in such cases to reduce factor *C* and increase factor *E* in the formula for unit cost of installation and operation with a corresponding reduction in the unit cost.

In the case of yard lighting, it is practical to decrease the unit cost of installation by the use of refractor equipment in place of ordinary reflectors. When refractors are used, the spacing can be made as great as 12 times the mounting height and illumination obtained of a uniformity equal to ordinary reflectors spaced four times the mounting height. By decreasing the number of posts and outlets, the installation cost for the yard lighting system is cut down.

The unit cost of operation can best be lowered by increasing the efficiency of the system, inasmuch as the cost of the current is the largest item of expense in factor *C* of the formula for unit cost of operation.

Comments by Other Illuminating Engineers

DAVIS H. TUCK: Since writing this, we have put in some industrial yard lighting systems and have found the unit cost of installation to be roughly 13 cents per 100 square feet of industrial yard. The illumination in foot-candles in such a yard is three-tenths of a foot-candle, the poles are about 30 feet high and are spaced 240 feet on centers, using 500-watt lamps. We have checked the unit cost on two yards, one of which came to 13 cents and the other 15 cents, which is fairly close.

To show you how that applies, I received a letter just a few days ago, stating that there were 5 acres of yards to be illuminated and they asked about how much this would cost. Evidently the man wanted to get an appropriation for lighting those yards and he wanted some idea as to the cost. Using the average of 13 and 15 cents which we had obtained for similar yards, we were able to give him a rough estimate of the cost of his yard lighting within $100 one way or the other. This illustration shows the practical importance of such unit cost figures.

H. W. DESAIX: I had both the pleasure and the privilege of collaborating with Mr. Tuck in the compilation of the information contained in his paper. I also know from actual experience that this works out very well in practice, particularly in some classes of industrial plants.

For instance, in the silk industry with which I am most familiar, building costs are actually handled on the basis of cost per square foot. In planning a new building or addition to an old one, the cost is not calculated on the basis of its cubic contents as is the case in some types of buildings, but is calculated on the basis of the number of looms times 100, which is the amount of space allotted per loom, including aisles.

Appropriations are based on the various factors which make up the cost of the building, reduced to a unit of cost per square foot. In the past such items as motor equipment and wiring for same have been figured on the basis of cost per loom and then divided by 100 which will reduce that to cost per square foot, but for allotting appropriations for lighting no figures have been available which would permit arriving at appropriations for this item. Obviously, the first thing to determine is the intensity required per square foot and then to prepare costs on the basis of the cost per foot-candle per square foot.

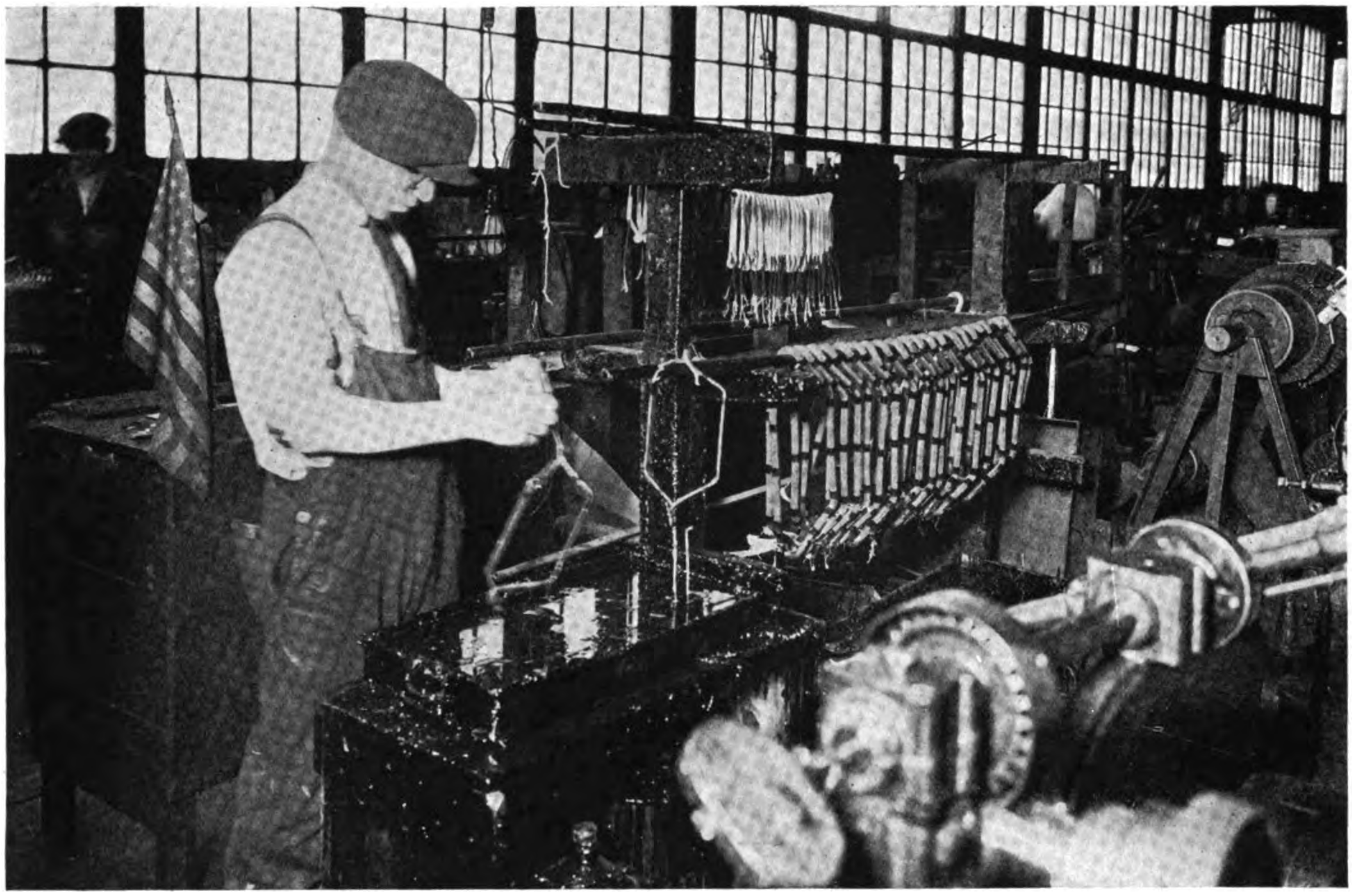
Mr. Tuck's paper was not intended to determine the comparative cost per foot-candle per square foot between various types of lighting units, but was compiled principally as a guide in preparing appropriations or approximate estimates on the cost of lighting installations for various classes of industries and equipment. It was also intended to show that by judicious engineering and by selecting proper reflector equipment that not only will high intensity, low unit-cost installations result, but that systems particularly adapted to the work can be obtained.

In arriving at unit costs it may not seem good reasoning to assume that for non-uniform systems the cost should be figured on the maximum intensity as if it were uniform over the entire area, but the plant executive is not particularly interested in whether the system is uniform or not just so long as he has sufficient light on the work with not too great a ratio between the maximum and minimum intensities. The plant executive paying for lighting is only interested in securing an efficient system of illumination which is so arranged as to be the most useful. If the non-uniform system is best adapted to the requirements it then becomes comparable with a uniform system where it is most desirable in so far as the unit cost is concerned.

Reference to Table I, items 1 and 2, will show that the ratio from maximum to minimum is only 2 to 1, which is accepted as good practice and not objectionable even for a so-called uniform system.

I noticed that Mr. Tuck, in his paper, states that the cost of lamps and labor for wiring and hanging the reflector equipment are staple quantities, the reflector equipment being the only items which may vary. That is true, but the quantity of those staple items will vary with the efficiency or inefficiency of the reflector equipment, because in some instances it is necessary to increase the size of the lamps in order to get the desired result, which increases the number of watts per outlet, and therefore, cuts down the number of outlets per circuit and hence increases the number of circuits.

L. E. ELLIOTT: It is necessary undoubtedly to estimate the cost of lighting on a strictly dollars-and-cents basis for a given room or amount of space. Manufacturers are still thinking of lighting as a wholly one-sided account on the ledger. It is an expense account, and the only thing they are particularly interested in is in keeping it down, so that the red ink balance on the other side may be as small as possible. But from the illuminating engineering standpoint, if we are going to promote better lighting we should look at it from the view point that is really interesting to the manufacturer. The *(Continued on page 356)*



This photograph shows the use of a shallow varnish pan by a large repair shop for dipping small coils of few turns.

Some of the Things to Consider

When Analyzing Coil Insulation Troubles

And Selecting the Best Varnish Treatment—Corrosion Troubles and Treatment for Different Wire Insulations are Outlined in Detail

By H. L. HAZELTINE

Engineer of Insulation, The Sterling Varnish Co., Pittsburgh, Pa.

IN THE ARTICLE that appeared in the June number Mr. Hazeltine outlined the best ways to use insulating varnish to protect windings against moisture, oil, metallic dust, and gave details of the methods of treatment. In this section he takes up a further analysis of insulating troubles and the treatment for enameled wire when used with and without cotton covering. Another section will deal with points to consider when selecting a varnish best suited to the conditions encountered in service.

FROM time to time complaints have been received about the non-drying of insulating varnishes. In general this is simply a case of improper treatment. All varnishes dry from the outside surface towards the center, so that during the initial drying period a skin forms over the outside and tends to retain some solvent and unoxidized varnish in the center of the coil. This really does no harm except that the insulation resistance is somewhat decreased (a good insulating varnish is an insulator, either wet or dry) and that throwing may possibly occur when this undried varnish is in considerable quantity, so that due to centrifugal force in moving parts it breaks through the outer crust and is thrown upon the frame or field coils. No harm may be done, but at the very least it results in a very unsightly appearance.

Baking Varnishes.—Some materials have been sold on the strength of the claim that they will dry from the inside out and that, therefore, drying can be obtained all the way through. These materials have not been a success as it has been definitely proved that they will also form a skin over the outside surface, and when such a skin is formed the oxidation of the varnish base is stopped.

Rather than select a material which must be sold by false claims it is much wiser to see what can be done towards remedying the difficulty by a proper method of treating the coils after the varnish has been applied.

Method.—In order to avoid the accumulation of undried varnish in pockets special attention should be paid to thorough draining; that is placing the coil in such positions

during this period that no pockets can possibly be formed.

Special attention should be paid to the oven. These varnishes dry by oxidation and, therefore, require a considerable quantity of fresh air during the drying period. See that this air supply is properly assured; then see that the proper temperature is being obtained.

Even when careful attention has been paid to these details trouble sometimes occurs, particularly in the case of coils of large cross section in which the thorough drying is hindered by the nature of the insulation, other than varnish, that has been used. In order to prevent the formation of a surface skin in such work many companies reduce the temperature of the oven during the initial baking period to about 150 deg. F. or less and gradually raise it to the desired point during the first two to four hours of the bake. In this way the solvent is evaporated before the actual oxidation of the varnish begins.

Air-Drying Varnishes.—The air drying varnishes are generally non-oxidizing materials. They dry principally by the evaporation of the solvent. Hence, if such a material requires too long a period to dry it is well first to examine the thinner that is being used in the shop. If it is not of the proper grade and contains heavy or slow evaporating fractions it will slow up the drying period amazingly.

If the thinner is the correct one to use attention should then be directed to the thickness of coat that is being applied. The heavy coats, of course, dry slower than do the thin ones. It is much better in such cases to apply several thin films than to try to secure the final results with a single treatment.

The same precautions should be taken to secure good draining as in the case of baking products. If the surface of the material dries so rapidly that the solvent is retained there is no more chance of obtaining thorough drying than if the varnish were left in the can and tightly sealed.

Lack of Color or Covering Quality

Sometimes complaints are received from the small user that the varnish which is being supplied to him gives no "color" or covering to his coils. This is due to one of two causes: Either the material which he is using is composed largely of

This coil was so badly corroded that it appeared as though green cotton-covered wire had been used.

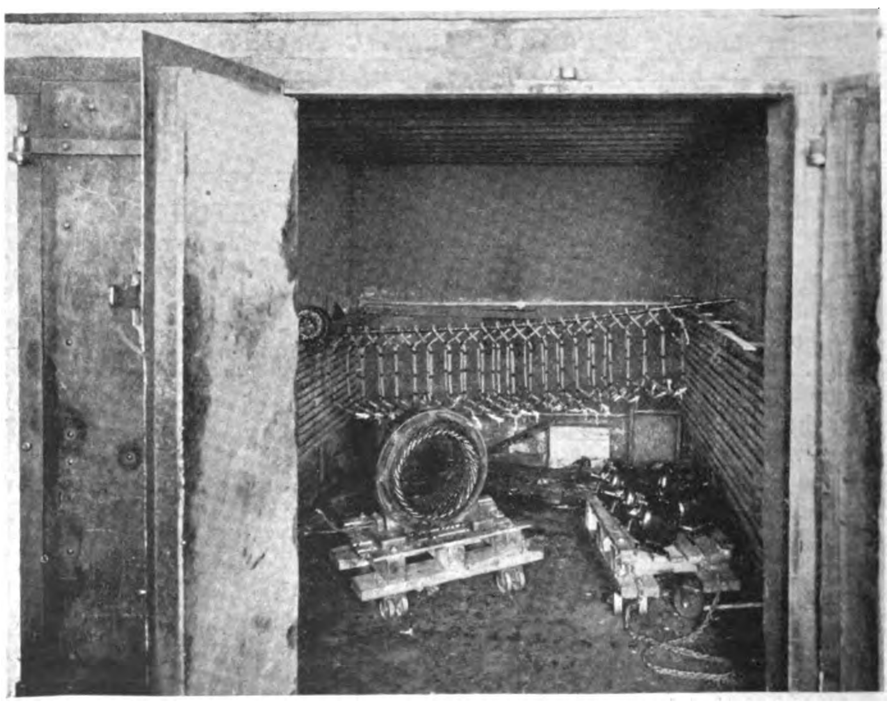
thinner and does not have sufficient base or useful material to provide the necessary protection or, more generally, it is because in using the material he has thinned it for special work and has either neglected to stir the thinner properly or else he has used too much of it. Proper attention to thinning, such as has been outlined in the article on *Insulating Varnishes and Their Solvents* (March, 1924, issue of INDUSTRIAL ENGINEER) will completely cure any trouble of this sort that may arise in connection with the use of insulating varnishes.

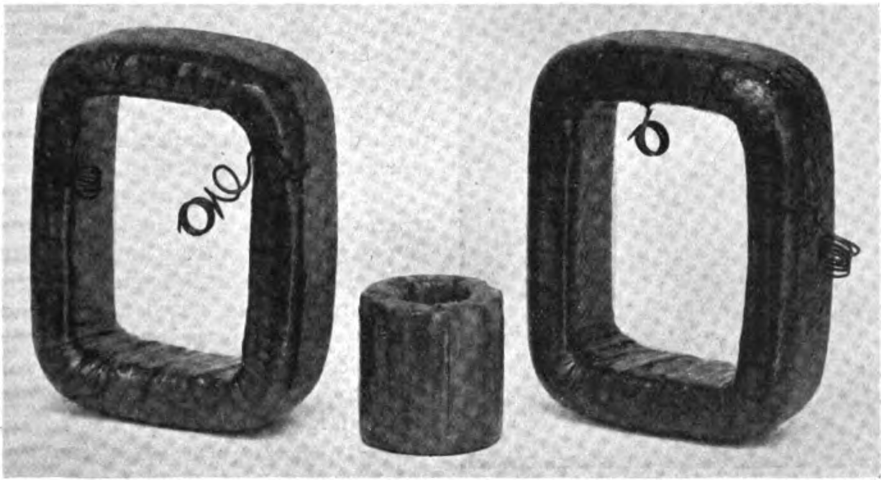
Baking varnishes dry by oxidation. During the baking period fresh air must be provided and the baking temperature regulated so that an outside skin will not be formed too quickly over the surface and stop the oxidation of the varnish base.

Causes and Prevention of the Corrosion of Wires

The corrosion or the turning green of copper treated with varnish is a problem which has in the past caused more uneasiness in the minds of the user than actual trouble. Most users of varnish know about what to expect and how to guard against this action and hence the subject is one of rather more academic interest than a vital cause of trouble. An article of this kind, however, would hardly be complete if we did not explain some of the causes of verdigris and show just what may be expected of any varnish. Some very excellent engineers have always maintained that the green deposit is a good insulator and therefore could not be the cause of the breakdowns which are sometimes laid at its door. Whether this is true or not it is unsightly and for that reason should be avoided if possible.

Nature of Corrosion.—Corrosion seems to be of two kinds, as evidenced by the turning green of cotton insulation. These are: (*a*) rapid corrosion in which the action becomes visible before the varnish sets or during the baking period. This must be due solely to a chemical action as there is no electrical cause to account for the change. (*b*) Electro-chemical breakdown of the varnish due to leakage or silent discharge which will form ozone or nitric acid if water should be present. This has been shown to be due to faulty insulation design and can readily be distinguished from the





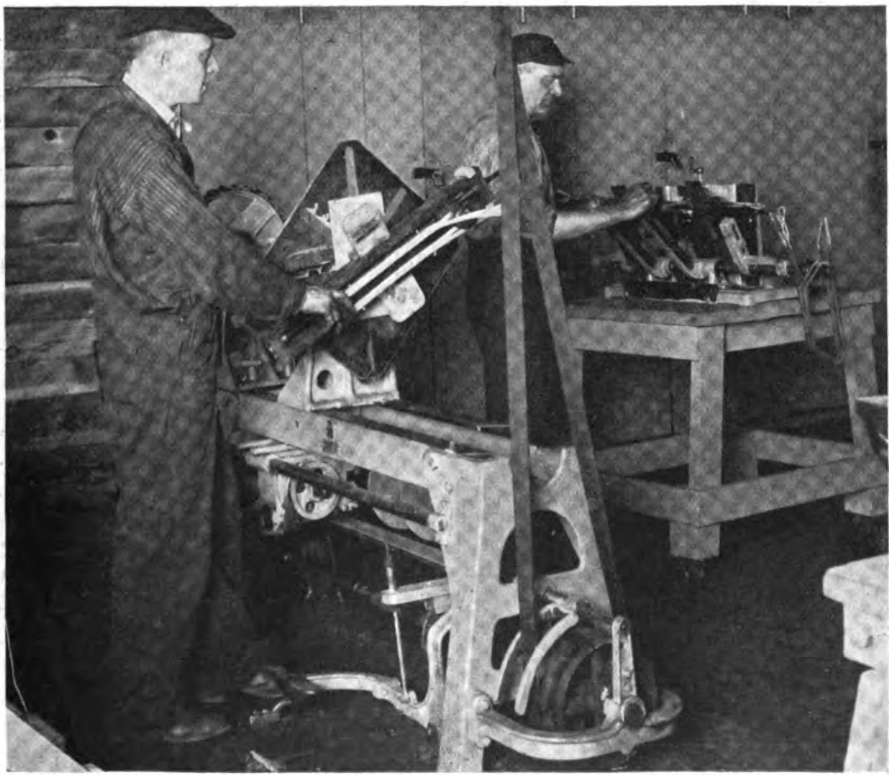
other, which is, therefore, the form of corrosion that most interests us and which we will enalyze.

Cause of Corrosion.—The oil insulating varnishes contain very weak inorganic or vegetable acids. They are present in the oil used but occur in larger amounts in the gums. It is the practice to neutralize these gums and then combine them with the oil by means of heat. It is impossible to neutralize the combination completely because of the danger of saponification and the resulting formation of a water-soluble soap.

The acid content of any varnish is so low and the acid itself is so weak that no action on copper can be observed due to the varnish alone. This can be proven by two simple experiments: (*a*) Take a clean strip of copper and completely immerse it in clear baking varnish. No signs of verdigris will appear whatsoever even after many days. (*b*) Take two clean copper strips and dip one of them in the same varnish. After thoroughly baking allow both strips to stand where they will be exposed to the atmospheric conditions. The untreated copper will after several days show signs of turning green and eventually will be completely covered with verdigris. The one that has been treated with varnish will show no signs whatsoever underneath the film. It would thus appear that not only does an insulating varnish not attack copper but that it actually prevents corrosion.

Troubles often arise from insulation other than varnish.

In the case of coils of large cross section thorough drying is hindered by the nature of the insulation. To prevent a surface skin in the drying operation, some shops reduce the oven temperature during initial baking to about 150 deg. F. and gradually raise it during the first two to four hours of the bake.



We must, therefore, look to some source other than varnish for the cause of this chemical action on copper. We are inclined to believe that this is moisture and perhaps oxygen. It seems quite probable when we consider the following experiment: Wind a spiral coil of copper wire about a small diameter rod such as a lead pencil, taking care that the turns do not touch one another. Fasten this vertically to the cork of a small bottle containing a small amount of a liquid varnish, but not enough to touch the wire. Push the cork into place with the spiral inside the bottle. Invert so that the varnish will come in contact with the copper and then place the bottle, right side up, where it will not be disturbed. A drop left on the coil will be found to stretch itself out between turns due to capillary attraction. After a time it will be observed that more or less green has been formed in the drop, indicating that some chemical action is taking place between the copper, wet varnish and air and moisture contained in the bottle. This progresses quite rapidly at first, results showing in from a day to a week, depending upon the varnish chosen for test. It reaches a maximum, however, where no further green appears when the varnish hardens by oxidation and thereafter goes no further. From this test and the two preceding ones several conclusions may be drawn. (1) Some cause other than varnish is responsible for corrosion. (2) This cause is probably oxygen and moisture in the air, since it may be observed in this second test that the maximum varnish and copper surface is exposed to reaction and hence humidity and oxygen are allowed their fullest play. (3) The

It is almost impossible to thoroughly dry a varnish on the inside of a layer wound coil having treated or untreated paper between each layer, by the application of heat from the outside.

The only places for the solvent to escape and for air to enter before the oxidation of the drying coils is through the ends. Another source of difficulty is that some repair men insist on forming coils after varnish treatment. In such a case the rapid baking products dry too hard to permit such an operation. The slow drying materials are sufficiently elastic but the coils are usually warm when they are formed and during this operation the conductors press against each other and may push the insulation softened by the combined action of the heat and varnish solvent, to one side and result in short circuits.

action is stopped when the varnish is completely oxidized.

In other words, just as in the rusting of steel, air and moisture must be present for the formation of verdigris. Copper exposed to air alone turns green in time.

In the second experiment where the copper strip was treated with baking varnish, water and oxygen were unable to get through the impermeable surface film and hence no corrosion was noted. It is further to be observed that enameled wire has never been known to develop verdigris even in coils which have afterwards been only partially dry. The reason can only be that air and moisture have been kept from actual contact with the copper.

Let us next consider the cotton tape or the cotton covering used on magnet wire. There are generally anhydrous acids left in these materials after bleaching. That the material is usually of an acid nature may readily be proved by placing a piece of wet, blue litmus paper upon it. It will turn red showing the presence of acid. Even worse than this, however, is the nap which is always present. These fine hairs allow air and moisture to be drawn through the varnish film which is supposed to cover completely. They also allow the straining out of the varnish by capillary attraction, just as was the case in the spiral and hence the exposure of the maximum copper surface to wet varnish, air and moisture which this nap assists in bringing in. Furthermore, the cotton also contains considerable moisture in itself.

You will now understand better one of the reasons why so much stress was laid earlier in this article upon the necessity for thorough drying of the coils before treatment and the obtaining of a perfect seal over the cotton insulation. Properly treated coils seldom show any signs of a reaction between copper, varnish, moisture and air.

In some shops armatures and stators are wound with white or untreated coils and the complete winding dipped in baking varnish. When this is done some slight degree of moisture resistance is usually sacrificed in order to provide mechanical or binding strength since the purpose of dipping the complete winding is to hold the coils in place and prevent their vibration, to fill all cracks between coils so as to prevent the deposit of dirt or moisture and to seal the laminations and to prevent their vibration, to cover the iron and prevent rust and to protect against oil which may be splashed on windings.

If a coil of copper wire which has been wrapped with cotton and treated with a single coat of a clear baking varnish is cut open considerable verdigris will be found, especially when it has not been preheated, even though practically none appeared when the test was made with the same varnish on the spiral coil in the bottle. It would, therefore, appear that any wet varnish containing an oil or fatty acid base may be acted upon by air and water during the drying period and that a certain amount of free acid may be formed from substances fairly well neutralized in the varnish.

One would, therefore, expect that when a varnish is applied by means of vacuum-pressure impregnation that an increase in the acidity of the varnish would be noted and this is exactly what has been observed in many cases. The explanation for this is as follows: In this process the coil is completely submerged in the varnish, air necessarily containing a certain amount of moisture is admitted over the surface and pressure is applied. This pressure must force the air and moisture into the varnish where it may act upon the varnish itself to cause an increase in acidity, or it may even be driven into the coils where it will come in contact with the copper. The results then would be the same as have been observed in other circumstances. This is one of the reasons why we have not recommended this system for varnish application to coil work.

Let us consider next some of the opinions of others. Some very good authorities claim that the green copper compound formed is an insulator and hence will do no harm. This is probably true for we know of no cases of trouble ever having been actually traced to this type of corrosion. (This does not refer to the electrochemical corrosion which is the result of faulty insulation.) This opinion is also borne out by the opinion of very excellent authorities who claim that the action is not one upon the copper but rather the action of the copper upon the varnish which would probably result in the formation of a copper soap rather than a copper salt.

Some engineers claim that chinawood oil varnishes show less corrosion than do linseed oil products. It is the writer's opinion that this has yet to be proved, although it is quite probable that the action will be arrested more quickly because of the more rapid drying of these materials. As has been stated before, the action ceases as soon as the varnish is thoroughly dry. A linseed oil

After dipping and baking operations, a coat of air-drying varnish is insurance against breaks in the continuity of the baked film.

product drying in the same length of time has been found to give equally good results. On the other hand some of the worst cases of verdigris have been in connection with chinawood oil products.

Measures for Prevention.—Since the varnish makers cannot at present control the action, the user must take it into account. Instead of blaming the varnish he should study his methods of application and so adjust them that the reaction cannot occur. This can be accomplished by preheating the coil thoroughly and then applying a sufficient number of coats to insure against interruptions of continuity. Where the condition is very severe a resort to singeing and sandpapering may help considerably.

Make sure that the varnish used is in good condition and that it contains a sufficient quantity of base or useful material to give good filling and covering to the work in hand. Remember that the larger companies who are doing the most careful work do not have corrosion difficulties. It is more often experienced by those who do not consider varnish of sufficient importance to waste any thought upon it.

Treatment for Enameled Wire

The treatment of coils wound with enameled wire is far from being an academic matter, as was the case of the preceding problem. It is a question which is giving considerable trouble today. As in all of the preceding cases, it can be largely controlled by careful treatment. It is not a thing for which either the varnish maker or the manufacturer of enameled wire can be blamed.

Causes of Softening of Enamel.—The enamel used on copper wire is in all essential respects an insulating varnish baked at a very high temperature. Hence, it will be softened by exactly the same conditions that will cause the softening of a varnish film.

It has been found that all varnish solvents, especially in the presence of heat, have a softening effect upon enamel—some more than others. Such materials as alcohol, acetone and all coal-tar products (such as solvent naphtha) have the greatest effect and hence varnishes containing any one of them in considerable proportions should not be used where they will come in direct contact with enameled wire. Petroleum distillates have the least effect. Varnishes containing a special grade of such products; that is, those which contain a very volatile petroleum distillate of narrow cut—containing none of the heavier fractions—will be found to have the least softening effect upon enameled wire and hence are most suitable for the treatment of coils wound with it.

One source of difficulty has been that some engineers have insisted upon forming their coils after varnish treatment. This is a very grave mistake. The rapid baking products dry too hard to permit such an operation. The slow-drying materials are sufficiently elastic, but the hot solvent remains in contact with the wire for too long a period. Hence the enamel may be softened. The coils are usually warm when they are formed and during this operation the conductors press against one another and may push the insulation, softened by the combined action of heat and varnish solvent, to one side, which will result in short circuits.

Remember that the difficulty is due partly to the nature of the solvent and partly to the length of time which this solvent is in contact with the wire and that this action is hastened by heat. In selecting a varnish for this work one should be chosen which contains a special solvent evaporating so rapidly that it remains in contact with the wire for as short a time as possible.

Process of Treatment. — Two methods of procedure may be followed in handling coils of this type. Either will give good results provided that careful attention is given to the details.

Impregnating Method. — Preheat the coils for a sufficient length of time to drive out the occluded air and moisture from the windings. This time will depend upon the size of the coil. Dip while still hot in a rapid baking varnish of the type described. Allow to remain for at least a half hour or until all bubbling has ceased and the varnish has been drawn into the interstices. Withdraw and drain for at least one hour to allow the varnish to partially set. Then bake at any temperature that will not injure the fibrous insulation, taking care that the bottom during draining is at the top during baking. Repeat this process as many times as are necessary to produce the finish desired. It will generally be found that after the first coat a shorter period of baking may be used, since these later coatings are largely surface films.

The result of this treatment is a well-filled coil with conductors well bound in place to protect them against mechanical strains. As there is little dead air inside the heat generated will be dissipated. The process is entirely suited to the treatment of small armatures wound with plain enameled wire.

The method, however, has this weakness when applied to coils of considerable cross section: During the baking a skin forms over the surface of the varnish and retains a certain amount of wet solvent in contact with the windings which in time will soften the enamel. This is especially true in cases where treated paper is used for layer insulation and in layer-wound coils where the only chance to dry the varnish is through the ends. "Shorts" may show up in such coils many months after they have been in service. Again, where very fine wire has been used the expansion due to heat causes the wire to expand and if it is held too firmly it bursts through the outer insulation.

Coils treated in this manner with the proper type of varnish cannot be formed after treatment.

Quick Dip Method.—Preheat the coil as before. Dip quickly while still hot in a very heavy-bodied, viscous varnish. Allow to remain in the bath for as short a period as possible—a few seconds at the most—withdraw at once and drain thoroughly. Then bake as before with the bottom during draining at the top during baking.

Because of the heavy consistency of the varnish and the quickness of the dip little penetration will be obtained; not over ¼ to ½ in. is desirable. As many additional applications should be made as will give the degree of protection desired.

The resulting coil is completely sealed against moisture, oil, acids, etc. The effect upon the enamel is obviated by the fact that little if any varnish actually comes in contact with the wire. The method is entirely adapted to coils operating on low voltage or intermittent service where little or no heat is generated and hence heat dissipation is not a factor. The process also has the advantage that the coils may be formed, since the conductors are not bound in place and hence have a chance to move.

Still another advantage is that the solvent can be thoroughly dried out without any danger of affecting the enamel. *(Continued on page 354)*

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Chicago, July, 1924

Inexperience Is a Target in Accident Prevention

FROM a study of 201 fatal accidents, the accident prevention committee of the National Electric Light Association in its report presented at Atlantic City last May, points out that nearly one-half of these accidents occurred to men who were inexperienced or new to the conditions under which they were working. Seventy-seven per cent occurred to men during the first five years of service.

These data point emphatically to the need for a periodic and careful check-up on machines, work and surroundings where there is a possibility for carelessness or inexperience to be the cause of a fatal accident. Such accidents, the committee also points out, frequently occur at starting and quitting time, when a competent foreman should always be on the job. At such times carelessness can usually be detected and the responsibility placed where it belongs.

The report mentioned contains thirty-five pages and provides useful information and suggestions to those who are responsible for accident prevention programs.

How Hot Are Your Resistors?

WHEN assuming the responsibility of keeping a drive in continuous operation, one of the first things that the maintenance man looks for is the spare resistors for the control apparatus. In many plants large stacks of spare resistors are a common sight. This is a condition that seemingly should be easily corrected.

Failures of resistors are usually caused by breakage due to vibration, by heating due to overloading and by grounding due to insulation failure. Breakage due to vibration is obvious and the usual motor inspector will correct this trouble without being told. Probably more failures are due to overheating than to any other cause. Overheating with its attendant excessive expansion and contraction of the resistor frames is also one of the most prolific causes of insulation failures.

According to "Standards for Industrial Control Apparatus" adopted May 16, 1924, by the Board of Directors of the American Institute of Electrical Engineers as presented at the annual convention in Chicago last month, and to the "Handbook on Controllers for Electic Motors" issued by the Electric Power Club, the limiting observable temperature rise should not exceed 350 deg. C., when the thermometer is placed in contact with the resistive conductor. In other words with a room temperature of 25 deg. C., a thermometer placed against a resistor grid should not read higher than 375 deg. C. How often is it the case, when walking through a control balcony or control house, to see resistor grids glowing a dull red, in other words working at a temperature around 750 deg. C.? We would not think of putting twice full load continuously on a motor. Why not apply the same thinking toward resistors? The standards mentioned above also specify that the temperature rise of the air issuing from the resistors, when measured one inch from the enclosure, shall not exceed 175 deg. C.

Replacing overloaded resistors with larger capacity resistors and careful determination of the proper size for the initial installation will not only greatly reduce maintenance costs and production delays, but will also reduce the capital investment tied up in non-productive spares.

The Human Nature in Man

IN A recent number of a publication issued by Lockwood, Greene & Company for the purpose of making known in an intimate and personal way the ideals and service rendered by its organization as consulting engineers, and mill-managing and operating engineers, the following item appeared under the heading of "Apple Pie and Golf":

> One thing C. S. Ching of the United States Rubber Company has discovered in dealing with all sorts of men, both big and little, is that no matter how rich they may be, or how high their social position, all of them are human beings.
>
> To illustrate their common humanity, he tells about overhearing the conversation of two boys. One of them said, "Gee, we had a great apple pie at our house last night, and I got a big, juicy piece. I bet you didn't have a pie as good as ours."
>
> "Huh," answered the other boy, "I'll bet your pie wasn't as good as our chocolate cake! I had a big piece of cake with chocolate all over it. I'll bet my piece of cake was better than your old piece of pie."
>
> On the train that same morning in the seat in front of Mr. Ching sat two business men, one the president of a corporation and the other the vice-president of still another big company. The corporation president told his companion how well he had played a certain hole on the Long Island golf course; whereupon the other man came back with a boast about what he had done out on the Westcnester-Biltmore course.

After all most people have many things in common—the trouble comes in finding just what these things are. The one that is most common is pride of accomplishment. If a man is doing worth-while things it does not take long to find out what he is most interested in. Plant managers can well take advantage of this trait in human nature, to the benefit of all concerned. Nothing is more gratifying among hard-working foremen than recognition of one or more things they are personally interested in. If it's associated with a company plan of operation no one thing can build up

interest and earnest co-operation in its execution like the enthusiastic support of a foreman. A little recognition once in a while, by the big boss, of a loyal department head or an individual who is doing original and creative work has a peculiar way of paying a large return in the form of advertising the human side of management and the general policies of an institution that make good men like to work for it and induce others of the same kind to join them.

There's a Place for You At the Top

MEN in charge of general maintenance throughout a large plant are about the busiest individuals in the works and they go from one thing to another almost on the run. This is so because they are in many cases trouble doctors, the men to whom others look for fixing up breakdowns, or locating troubles that are holding up work at machines and causing operators to stand around with nothing to do. But when one job is fixed up, on they go to the next and the next from the time they reach the plant in the morning until they leave it at night. After a time they get to know a lot about the weak spots in the plant equipment; the causes of troubles that might be prevented; the carelessness of certain operators, and the ways certain equipment might be changed or rearranged to improve its operation.

Men who have the opportunity of such training and experience and become experts in their work, nowadays have a chance to go up the ladder of responsibility faster than any other skilled mechanic if they possess or acquire one thing—initiative.

Elbert Hubbard once defined initiative as doing the right thing without being told, or at least doing it when you have been told once. It's a little more than this for it's doing a thing right and knowing why; making it your business to make sure that the executive to whom you report knows the details of why things go wrong and presenting the reasons in such a way as to let that individual know that you are interested in preventing troubles as well as curing them; that you have an interest in his problem of production and the elimination of wastes and excessive costs. If you fail to get your point across by talking to him, then write out your suggestions and comments and ask to get the privilege of showing him the things you believe should be done. Just don't give up until you are sure that your viewpoint has been fully understood—that's determination plus initiative and it's the thing every works manager is looking for and willing to pay for when backed by an expert working knowledge of how to do things or get others to do them.

Recently in an eastern plant a maintenance engineer who had been in charge of factory repairs and changes for a number of years was selected as the head of the production division. It came as a surprise to him but it was based upon observation of his work. That man was never contented to do merely routine work in his department but was always ready to help any one by making suggestions and working with him in carrying them out.

He had demonstrated his executive abilities in his own department and knew the technique of maintenance work from start to finish in every other department. Year by year as he went about the plant he absorbed fundamental knowledge of process work, kept in close contact with foremen and their problems and devoted the energies of his staff to giving the best possible service in cutting down delays and preventing troubles.

In his new work his superior feels sure that he will follow the same procedure and combine his experience in maintenance and plant engineering generally with his insight into process requirements. It is a safe bet that the productive efficiency of the entire factory will be put upon a new and higher plane. The ability of this engineer to acquire the mental angle of the production man while going about his regular duties is not unique, but it suggests to other maintenance engineers, who sometimes are tempted to wonder "where they are heading in" when busy with the seemingly endless round of repair jobs required to keep a great industrial organization profitably at work, that the man who gets ahead is the one who goes about his job in the same way as though he owned the whole works and had to meet the payroll every Saturday morning. Such men don't need a pull to get ahead, they need determination, initiative and good health—that's all.

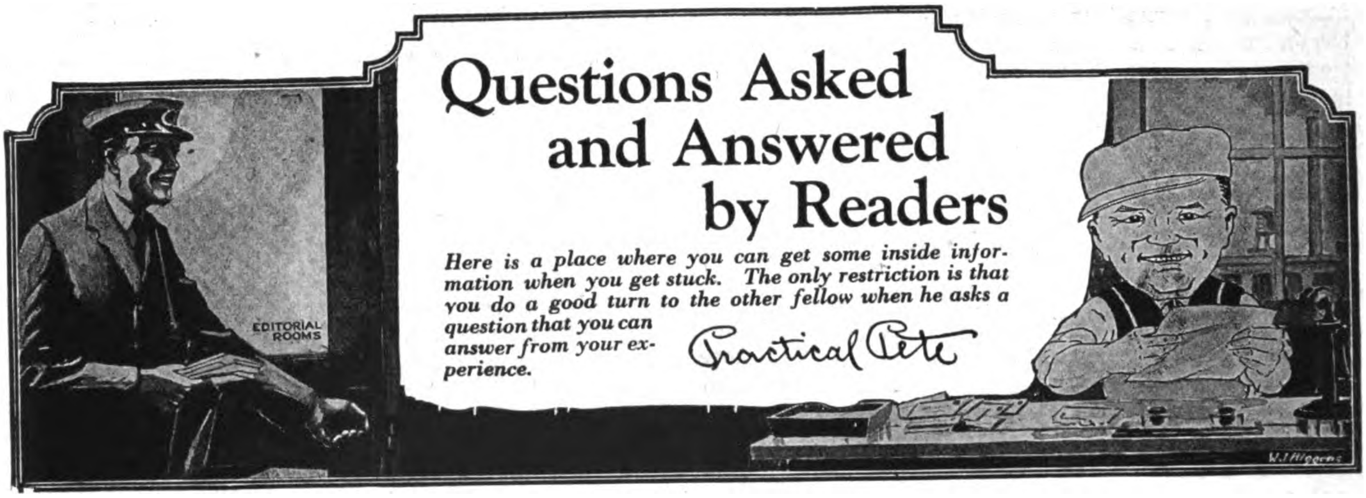
Self Interest Is the Basis of Co-Operation

UNDER the best of conditions the maintenance engineer of a large works has a man-sized job. In addition to the mechanical and electrical problems which must be solved in keeping equipment in proper operating condition, he must manage somehow to secure and keep the co-operation of the various foremen and department heads. Without the co-operation of these men it is very difficult or impossible for the maintenance department to work to the best advantage. The foremen of other departments can do much to help or hinder the work of the maintenance department.

How this co-operation can be secured is a problem to which various answers could be given, and probably no one answer will fit all conditions. Every foreman has his own troubles to worry over and it is perhaps only natural that he should be inclined to pay little attention to the maintenance department and its problems—until one of his motors or machines breaks down. Most of us find it difficult to take much interest in things that we do not know much about, and that do not appear to affect our personal welfare directly.

In an article which begins on page 312 of this issue, Mr. Woodbury tells how the various department foremen of The Wahl Company were led to give their enthusiastic support and co-operation to the work of the maintenance department, through a system of monthly reports which show the charges made against each department. In order to keep some of these charges down to a minimum it is necessary for the foremen to cooperate with the maintenance department in keeping equipment in good condition and preventing breakdowns. Thus, co-operation with the maintenance department becomes a matter of education rather than compulsion or discipline. The foremen can see where maintenance work directly affects their record as executives; it is a useful tool, not a theory or something for the other fellow to worry about.

Securing the co-operation of an individual or a group of individuals is largely a matter of showing what such co-operation will do for them. Self-interest will do the rest, where argument or compulsion might fail.



Who Can Answer These?

Moisture-Proofing Treatment For Motors in Pulp Mills—I wish some of the readers of INDUSTRIAL ENGINEER would tell me what method or treatment they use for keeping moisture out of the windings of motors and other electrical equipment which is located in very damp places, particularly in paper pulp mills. I shall be very grateful for any information you can give me.
Temiskaming, Que., Can. J. H. S.

* * * *

Methods of Repairing Wooden Floors—We have found that the wooden floors in the trucking aisles and particularly at corners where trucks are turned, wear more rapidly than the remainder of the floor. I would like to know the experience of some of the other readers of INDUSTRIAL ENGINEER in making repairs for these sections of the floors. Also, we would like to know whether our readers favor flooring laid parallel to the line of trucking, crossways, or on a diagonal.
Monmouth, Ill. J. H.

* * * *

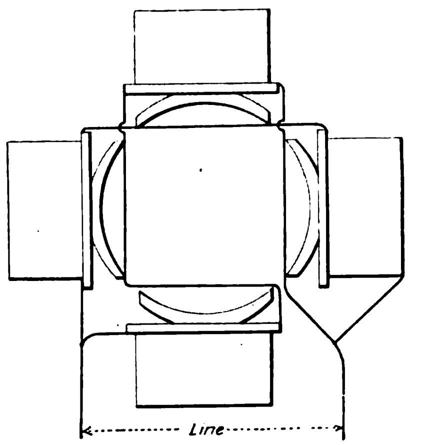
Can Direct Current Be Obtained from Ford Spark Coil?—Will some reader please tell me (1) if I can connect a Ford spark coil to a 110-volt line through a 6-volt, step-down transformer and use it for the ignition system of an engine? (2) Under these circumstances would the high-tension side of the coil deliver a.c. or d.c.? (3) What is the voltage on the high-tension side of one of these coils? (4)Can I put 110 volts a.c. on the high-tension side and charge a storage battery from the low-tension side? (5) Can you tell me how to make a good rectifier for charging storage batteries?
Bellingham, Wash. E. M. D.

* * * *

Construction of Pipe Rails and Guards—We have found it necessary to make some pipe rail guards to extend alongside some of our machines to prevent trucks from getting too close to them and also to provide a free aisle alongside the machines for the operators. As we wish to make these easily removable, I wonder if some of the readers of INDUSTRIAL ENGINEER could offer any suggestions as to how these can be made sectional, the size of pipe to use, kind of fittings, construction of floor sockets, the span between supports, the most convenient length of sections and methods of connecting the sections.
Peoria, Ill. G. G. H.

* * * *

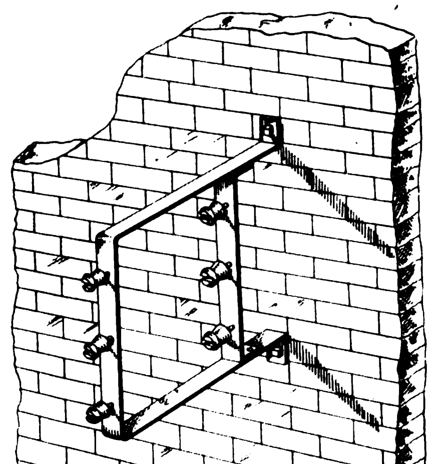
Stator Connections for Old-Type G. E. Fan Motor—I have an old-style, General Electric, 110-115-volt, 60-cycle, single-phase fan motor of the squirrel-cage rotor type, with spool-type stator windings. The original field coils, which were burned out, contained 170 turns of No. 20 d. c. c. wire. As I did not have any No. 20 wire at the time, I rewound the coils with 200 turns of No. 22 d. c. c. wire. Two coils were spool-wound, while two coils were of the honeycomb type. I connected these coils as shown in the diagram. I do



not know what sort of control apparatus was in the base of the fan, but with the connections shown the motor attains a speed of 1,600 r. p. m., but heats up rapidly and would roast out if allowed to run for a time. Will some reader please help me out on this?
Ottawa, Ont., Can. S. J.

* * * *

Will These Brackets Cause Trouble?—I am sending a sketch of an iron bracket which is to be used for supporting two sets of feeders for a three-phase, 550-volt system. Considering that the brackets are made entirely of iron, I should like to know if there would be



any inductive or other action if 20 or 25 of these brackets were used. If so, could it be eliminated by making the brackets of brass or copper? Will someone please advise me what to do?
Hastings-on-Hudson, N. Y. S. S.

Answers Received To Questions Asked

I want to thank the readers who were kind enough to give me so many good answers in the January and April, 1924 issues of INDUSTRIAL ENGINEER, to my question regarding the charging rate of storage batteries. To me these answers were worth the price of my subscription many times over.
Temiskaming, Que., Can. J. H. F.

* * * *

Air Filter for Intake of Air Compressor—I should like to get a little information from someone who may be inclined to lend a helping hand. The plant where I am employed has installed two feather-valve air compressors. These compressors are subjected to coal dust, coal smoke and sand and we are having trouble with the valves. After cleaning them they operate satisfactorily for about 24 hours, and then begin to hang and stick.

Will someone please give me complete details of a suitable screen or air filter that I could make and use on the intake of these compressors?
Norfolk, Va. W. B. E.

We note a question by W. B. E. in the May issue in which information is requested in relation to air filters for compressors. We note that the compressor in question takes in air which is filled with coal dust, sand, etc., and it is quite natural that trouble with the valves would result.

It would be our recommendation that the reader install an air filter on the suction of these machines, and we can refer him to the Reed Engineering Company of 50 Church Street, New York, who would be glad to furnish such filter.

Your client should give the Reed Engineering Company full information regarding the capacity of the machine and size of suction opening.

We are sending you two copies of this letter so that you may forward one to your client if you so desire.

R. D. BROOKS.
Manager, Air Compressor Dept.,
Worthington Pump & Machinery Corp.,
New York, N. Y.

* * * *

In reply to the inquiry by W. B. E. in the May issue of INDUSTRIAL ENGINEER, in regard to air filter for intake of air compressor, I would refer you to bulletin T-3516-2 put out by the Westinghouse Traction Brake Company, Pittsburgh, Pa., showing centrifugal dirt collectors and strainers.

Perhaps there is something in this which will help you out in your dif-

ficulty. On the street cars, we use a strainer similar to that shown on page 5, piece No. 67900, and find that we have very little trouble with dirt or dust in the compressor. However, the curled hair should be removed from the strainer and washed thoroughly in gasoline at regular periods.

Asst. Supt. of Equipment. R. S. NEAL.
The Kansas City Railways Co.,
Kansas City, Mo.

* * * *

Correcting Power Factor by Synchronous Condenser—I wish to submit the following problem to our readers: *A* is a distributing station supplying power to four feeders, *B*, *C*, *D* and *E*; *B* takes 4,000 kw., *C*, 3,500 kw., *D*, 3,000 kw., and *E*, 2,000 kw. The power factor of these loads is: *B*, 80 per cent, *C*, 78 per cent, *D* 75 per cent and *E*, 72 per cent, all lagging. It is desired to install a synchronous condenser at station *C*, to give 95 per cent power factor. Would it make any difference in the size of condenser required at *C* if stations *B*, *D*, and *E* were to correct their power factor to unity instead of running at 80, 75 and 72 per cent respectively, as at present, (1) in case station *A* has ample generator and exciter capacity and (2) in case this capacity is just enough to carry the load?

Belleville, Ont., Can. J. H. G.

In looking over my reply, in the May issue, to J. H. G.'s question I find that I made an error in my answer. I evidently copied the wrong value for the synchronous condenser and gave the reactive kva. instead of the actual condenser capacity, which should have been 6,300 kva. The second paragraph of my answer should, therefore, read: "(1) Under the first set of conditions, to raise the power factor to 95 would require a synchronous condenser with a capacity of 6,300 kva., operating at zero power factor leading," etc. The value of 1,000 kva. given under Case 2 is correct.

I regret that this error was made and want to take this opportunity of correcting it. C. OTTO VON DANNENBERG.
The J. G. White Engineering Corp.,
New York, N. Y.

* * * *

With reference to the problem submitted by J. H. G. in a recent issue of INDUSTRIAL ENGINEER, it is evident that power factor correction is desired at station (A), as a condenser at station (C) will only affect the power factor in the line between stations (A) and (C) and on the bus bars and generating equipment at station (A).

Considering the correction of power factor at station (A) by a condenser at station (C), assume that the diagram is drawn to scale, letting the ordinates (vertical lines) represent wattless inductive kva., the abscissas (horizontal lines) represent kw. and the diagonals (hypothenuses) the total kva. of the various stations as follows:

Station (B); (ab) equals 4,000 kw.; (bc) equals 3,000 wattless lagging kva.; (ac) equals 5,000 kva. delivered to station at 80 per cent power factor.

Station (C); (cd) equals 3,500 kw.; (de) equals 2,800 wattless lagging kva.; (ce) equals 4,500 kva. delivered to station at 78 per cent power factor.

Station (D); (ef) equals 3,000 kw.; (fg) equals 2,640 wattless lagging kva.; (eg) equals 4,000 kva. delivered to station at 75 per cent power factor.

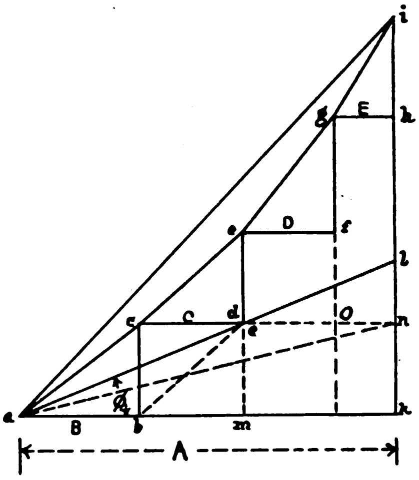
Station (E); (gh) equals 2,000 kw.; (hi) equals 1,930 wattless lagging kva.; (gi) equals 2,780 kva. delivered to station at 72 per cent power factor.

Station (A); (ak) equals 12,500 kw. output; (ki) equals 10,370 wattless lagging kva.; (ai) equals 13,160 kva., total delivered by station. Power factor equals (ak) divided by (ai), or 77 per cent.

If (al) be drawn so that cos Φ equals 0.95, the line (al) will represent the kva. at station (A) when delivering 12,500 kw. at 95 per cent power factor. Then (kl) will represent the wattless lagging kva. at the same time. Line (il) will represent the leading power factor required to correct the power factor at station (A) to 95 per cent. The size of condenser, as indicated by this line, will be approximately, 6,240 kva, when operated at zero leading power factor.

Placing a condenser of this capacity at station (C) will change its power factor from 78 per cent lagging to approximately 48.6 per cent leading and would cause a wattless load in its feeders considerably in excess of the value before correction.

Referring to the diagram, if stations (B), (D) and (E) are raised to 100 per cent power factor, (ab) equals 4,000 kw. at (B) at 100 per cent power factor; (bm) equals 3,000 kw. at station (C) at 78 per cent power factor; then (me') equals 2,800 wattless lagging kva. at (C); (be') equals 4,500 kva. delivered to station (C); (e'o) equals 3,000 kw. at (D) at 100 per cent power factor; (on) equals 2,000 kw. at (E) at 100 per cent power factor; (an) equals 12,800 kva. output at station (A). Power factor equals (ak) divided by (an), or 97.6 per cent power factor at station (A).



Graphic method of determining size of condenser needed for power factor correction.

Since the power factor under this condition is 97.6 per cent no condenser is required at (C).

The diagram was purposely distorted to show more clearly the method used and it should not be scaled to verify the above figures.

In the writer's opinion, a condenser is not warranted in this instance, but if the main station is loaded to such a capacity that it should be considered, the money necessary to purchase the condensing equipment could be better applied to additional power plant equipment. If the generator has sufficient capacity, there is no need to worry.

Wilmington, N. C. CHARLES R. SUGG.

Supporting Load from Concrete Ceiling—In rearrangement of the plant with which I am connected, we frequently find it necessary to suspend conveyors, motor platforms, countershafts, heavy radiators, and similar equipment from the ceiling of a reinforced concrete building. I am wondering if any of the readers of INDUSTRIAL ENGINEER have any information on how heavy a load can be supported from expanded bolts. I would also like to find out what other readers consider the best method of fastening equipment to the ceiling.

Chicago, Ill. E. D. F.

Referring to E. D. F.'s inquiry in the April issue, by far the cheapest and easiest way to attach a heavy load to a concrete ceiling is to drill right through it and screw bolts into flat plates. If desired the plates can be sunk below the level of the floor above and a concrete patch put in.

Of course, if the ceiling is the roof, it will be necessary to make the job water tight, but there are plenty of roofing compounds which can do that.

Plainfield, N. J. CHESTER L. SEYMOUR.

* * * *

In answer to E. D. F.'s question in the April issue, the literature on the holding power of expansion bolts set in concrete is quite limited. Merriman, in his "American Civil Engineer's Pocketbook," third edition, page 591, states that expansion bolts, when imbedded in 1:2 portland mortar, have an ultimate holding power of 264 lb. per sq. in., and adds that a working unit stress of about one-fifth of this, or 53 lb. per sq. in. should be used.

Turneaure and Maurer in their "Principles of Reinforced Concrete Construction," second edition, page 216, state that the bond strength of plain steel is 200 to 250 lb. per sq. in., from which a working stress of 60 to 80 lb. per sq. in. is suitable. They further state "For deformed bars having a positive grip, a working stress of 150 lb. per sq. in. gives an ample margin of safety."

Let us apply this to a particular brand of ½-in. bolt and anchor. Roughly, the anchor is 1 in. in diameter and 2 in. long, making an area of 6.28 sq. in. imbedded in concrete. At 150 lb. per. sq. in. this would give a holding power of 942 lb. Allowing 10,000 lb. per sq. in. tensile strength in the bolt, which ought not to be exceeded, a ½-in. bolt is good for 1,260 lb. in tension. This would show that, for this particular case, the anchor would be weaker than the bolt.

There are a number of types of expansion shields on the market, ranging in size from those for small wood screws to those for 1-in. bolts. Each manufacturer claims that his particular product is the best and asserts that when properly applied the bolt will break before the anchor pulls out. This may be true in all cases where properly installed, but unless the workman is thoroughly familiar with this class of work, the shields will not be properly installed. This is especially true of the malleable and composition anchors on the market. Proper drill size is absolutely necessary for the correct installation of these anchors.

The "Pierce" lead sleeve expansion bolt comes in sizes of ¼ in., ⅜ in., and ½ in. and of varying lengths and has been found to be very effective in these sizes. For bolts larger than ½ in., mal-

leable anchors of either the "Sebco" type or the "Keystone" type have been used here with success. The latter has been used to support 1-ton trolley tracks mounted on a concrete ceiling.

Practically, I should hesitate to depend upon an anchor's developing the same strength as its bolt and, to allow for poor workmanship, would say that no anchor should be called upon to develop more than one-half of the working strength of the bolt.

Fort Worden, Wash. E. I. PEASE.

* * * *

Answering E. D. F.'s question in the April issue, expansion bolts used for overhead loads on a concrete ceiling are safe only for small areas and not very heavy loads, and where serious vibration is absent. The safest way to suspend heavy loads is to use strong split clamps bolted to I-beams. If the beams cannot readily be located in the ceiling at all points, light rails or small I-beams can often be supported from such beams as can be located. Then countershafts, platforms, etc., can be readily clamped to the exterior I-beams.

Expansion bolts are likely to crack out pieces of the concrete ceiling if drawn up too tightly, and if left a trifle loose they are liable to work out. The only safe fastening for a heavy overhead load is clamps on the flanges of beams, or bolts in drilled holes, with lock washers or double nuts.

By the methods shown in the illustration the writer has supported motors up to 1,000 lb. in weight on exterior I-beams bolted to the beams imbedded in the ceiling. If the span is very great use heavier beams to support the loads, and as many as are needed may be placed side by side.

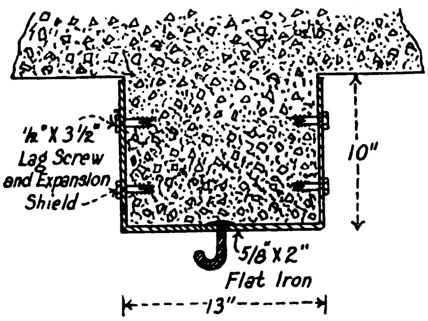
Expansion bolts are all right in concrete floors and for some kinds of light, motionless loads on side walls, but for heavy loads on walls and ceilings they are not to be trusted, principally because they are liable to work loose, no matter how long or what type they are.

New Britain, Conn. H. S. RICH.

* * * *

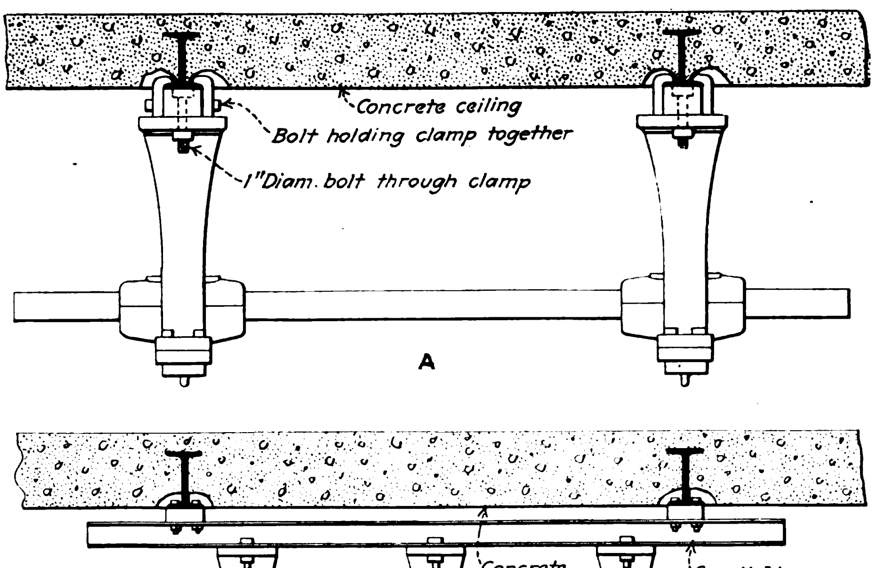
Referring to E. D. F.'s question in the April issue, I have had to solve this same problem and finally made a strap or detail which has given very satisfactory results. This strap, which is shown in the illustration, was made of 5/8-in. by 2-in. flat iron and was used on concrete ceiling beams. It was attached to the beam by means of 1/2-in. by 3 1/2-in. lag screws and expansion shields set in the beam. The hook was made from a piece of 5/8-in. round iron. The upper end of the hook was peened over so that the strap would fit close to the beam. I might suggest that if this hooked strap, as shown, is undesirable holes may be drilled and tapped for bolting any type of support to the strap. I sincerely hope that E. D. F. will find this strap to be the solution of his problem.

Dallas, Tex. F. J. H. KRAUSE.



A flat iron strap fastened around the beam by lag screws and expansion shields and fitted with a hook forms a convenient support for heavy weights.

Heavy loads may be suspended from the ceiling by split clamps around the beams, (A), or from I-beams bolted to the ceiling beams, (B).



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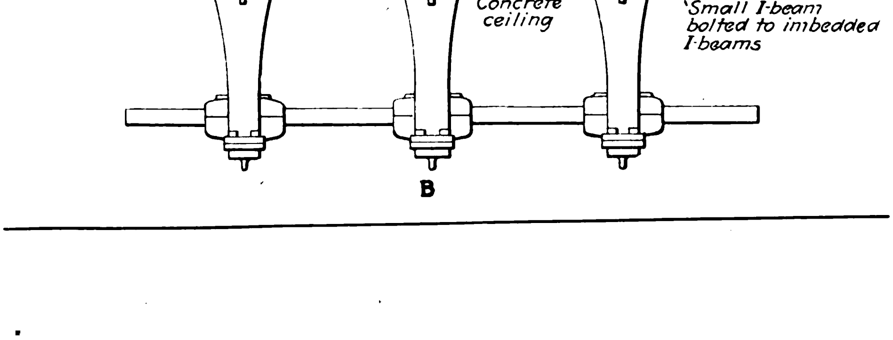

B

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Installing Signal Lamp on Single-Phase Electric Furnace—Can any of our readers tell me how to install a signal lamp on a single-phase electric furnace? There is a switch on the primary side of the transformer that furnishes current for the furnace, and I wish to find some way of installing a light between the top carbon electrode and the bottom contact, so that when the switch is released by a short circuit from a piece of metal falling against the carbon electrode, we can tell by this light whether the electrode has been raised high enough to break contact with the metal, before throwing in the switch.

The winding in the transformer forms a permanent circuit, so that we cannot apply any outside source of current to operate this light. It would save us considerable money if we were able to connect up a light of this kind, as the cost of carbon electrodes and contacts for the switch runs into considerable money. I shall appreciate very much any suggestions which you can give me.

Michigan City, Ind. P. V. H.

Answering the question by P. V. H. in the March issue, inasmuch as the winding in the transformer forms a permanent circuit, there seems to be no way to attach a lamp circuit to the electrodes without cutting in on the secondary. If it would save considerable money to have such an indicator I would suggest cutting in a heavy, double-throw, double-pole knife switch, which would disconnect the transformer secondary circuit and at the same time connect in an outside lighting circuit. The indicator should consist of at least two lamps, so that no delay would be caused if one should burn out.

New Britain, Conn. H. S. RICH.

* * * *

Trouble with Single-Phase Motor—I have a 1/6-hp., 110-volt, 60-cycle, single-phase induction motor of the split-phase starting type, having its windings on the rotor and the squirrel cage on the stator. This motor recently showed evidence of heating when running on light load and finally refused to start, even without load. On testing the windings, they were found to be free from opens, shorts and grounds. The centrifugal switch functions all right but shows burning at the contact points. The bearings were renewed and the contact points cleaned, after which the motor started on no-load when first reassembled, but after that it again refused to run. The rotor was free in the bearings and did not rub on the stator, also the brushes were operating all right. Will someone suggest what may be the cause of the trouble?

Newark, N. J. H. M.

In reply to H. M.'s question in the May issue, I am inclined to think that his trouble is in the stator, assuming the motor tests were correctly made and no defects found. Troubles in rotors of induction motors are not particularly common. H. M.'s motor may have been running at times with a temperature high enough to melt the solder at the joints of the bars and short-circuiting ring. High resistance at the loose joints might have caused the motor to heat sufficiently for this to happen.

Loose joints manifest themselves by

a rattling noise, in the case of a squirrel-cage motor. Inasmuch as his motor has the squirrel cage on the stator the rattling noise mentioned above is not very noticeable.

New Orleans, La. OVIDE C. HARRIS.

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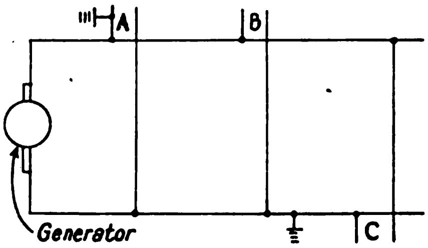
Why Do Grounds Not Blow Fuses in Power House?—It always takes two grounds of opposite polarity to make a short circuit. In cities or in large industrial plants where there is much conduit work, there must be grounds. If there is a ground on the negative side of one building and a ground on the positive side of another, why would these not blow the main fuse or open the breaker in the power house? Again, under the conditions shown in the diagram, when testing out building *C*, would it not be possible to obtain results which would make one think that there is a ground somewhere in this building whereas it is located in building *A* or *B*?



Worcester, Mass. F. R. B.

In reply to F. R. B.'s question in the April issue, I would say that the fuses do not blow nor the breakers open because the short circuit is of very high resistance. The current is not strong enough to open the circuit. However, it represents a power waste even though it does not interrupt service.

It is possible to obtain the results you mention. In a case like this it is always advisable to open the entrance switch and thus eliminate the danger of picking up a ground from another part of the circuit. This might lead to a good deal of confusion and loss of time before the real situation was discovered and corrected.

SGT. JAMES A. COOKE.
Observation Battery,
Fort Bragg, N. C.

* * * *

In reply to F. R. B.'s question in the April issue, with two grounds on the opposite polarity of a system, the main fuse will blow or the main circuit breaker will open only if the resistance between the grounds is low enough to allow sufficient current to pass through to trip the circuit breaker or blow the fuse.

If the grounds have a high resistance, as when they are due to dampened, worn insulation, or through dust or some partially conducting medium, it is doubtful whether any effect will be noted, other than an indication on the ground detector. Should the voltage be high enough and sufficient current flow through the conducting medium to the ground, it is possible that there might be local heating, or even danger of fire if the surrounding conditions are favorable.

It is the practice of some companies to make tests to determine the resistance of grounds even to the extent of using various sizes of fuses to blow under certain conditions.

When testing for grounds in certain buildings, the existence of a ground in a particular building can only be definitely determined by opening the main supply switch to that particular building and then making tests. A ground on other parts of the system or in any other building will lead to confusion regarding the particular location of the ground when the whole system is interconnected.

When the whole system is installed in iron conduit or in lead-covered cables, grounds on opposite polarities will usually have a sufficiently low resistance to give a definite action of the fuses or circuit breakers.

C. OTTO VON DANNENBERG.
The J. G. White Engineering Corp.,
New York, N. Y.

* * * *

Answering F. R. B.'s question in the April issue, where the ground appears on both sides of the line in separate buildings there is enough resistance in the earth to keep the fuses from blowing or the circuit breakers from opening, and yet the ground indicator at the power station will indicate the heavier ground. This is a common occurrence on d.c. circuits where motors are used mostly for operating elevators or other apparatus and are placed in damp basements.

It is not possible for both grounds to show in the same building. When testing for a ground the heavy ground will show on the test lamps until it is removed; then the ground will show on the other side of the line. Upon pulling the main switch of that building the ground will show up on the main outside circuit, and can easily be traced to the other building.

I have found that the best way to test for this kind of a ground is to use test lamps, connecting enough lamps in series to carry the voltage, and making a test at the cabinet center by cutting out each circuit and testing for the ground.

Time is often saved by pulling the main switch of the building and then testing for the ground. One must keep in mind which side of the circuit the ground is on because, as before stated, indications of a ground will appear on the other side of the line as soon as the heavy ground is removed.

Knoxville, Tenn. W. P. AMANNS.

* * * *

With reference to F. R. B.'s inquiry in the April issue, a discussion of why main circuit breakers do not open due to grounds on both sides of the line involves several points.

(1) If the grounds do not appear on the same machine, there is an appreciable resistance between them which limits the current. The writer measured the resistance from a water pipe to the angle iron supporting a switchboard, 20 ft. distant. The angle iron was fastened by expanding bolts to the concrete floor, which was laid directly on the ground. The actual resistance was 50 ohms. This resistance, on our 220-volt lines, would permit a flow of 4.4 amp. if both legs were solidly grounded.

(2) In a properly designed system the main feeders are better insulated and as they carry more current than the smaller branch circuits, the lines are fused accordingly. Assume that the main distribution panel is fused for 600 amp.

One feeder circuit goes to an individual building panel where we find the circuit split and the main fuse on that board to be 150 amp. These branches are distributed to various lighting circuits and machines with their individual fuses of 20, 40, or 60 amp. rating. As grounds appear most frequently at the machine, the smallest fuses would be the first to go and thereby protect the main circuits.

(3) If all circuits are periodically inspected, using a megohmer to test the insulation resistance and these tests are tabulated, deterioration can be watched and checked before any damage is done.

As to the location of the grounds, we always pull the switches or fuses of each building when testing for grounds. One bad spot, therefore, appears only in the building which is being tested at the time.

If the circuits must be tested while they are hot, there is on the market a patented ground locater for running down the ground without any possibility of error. By listening in with an ear phone at different points along the feeder, a sound is heard only at those points where ground current is passing through the copper tested. As soon as the grounded machine is passed, the phone is silent. In this manner, grounds can be traced with certainty down any number of branches.

CHESTER L. SEYMOUR.
Plainfield, N. J.

* * * *

Preventing Corrosion of Iron Storage Battery Racks—I should like to ask your readers what treatment can be given to iron racks for storage batteries which will prevent the spilled acid from attacking the iron. We use the lead type of battery filled with dilute sulphuric acid. We have a large number of storage batteries and recently some iron racks have been constructed. All of these racks were painted with several coats of the best grade of asphaltum black paint but this does not protect the iron when acid is spilled on it, nor does any kind of paint that I have tried.

We have had considerable trouble due to the corrosive effect of the acid forming a substance resembling sand which falls into the jars below. This produces excessive iron in the solution, making a change of acid necessary. I shall appreciate it if anyone can tell me how to overcome this.

Atlanta, Ga. J. B.

In reply to J. B.'s question in a recent issue, as the result of experimenting with several different preparations in an effort to prevent corrosion of battery racks and busbars I would suggest that he thoroughly clean off all old paint and corrosion from the attacked parts and then wash them with a solution of bicarbonate of soda. Dry thoroughly and apply two coats of Pyramid Acid Resistor Paint, either flat or gloss, or both.

If he does this I am sure that the trouble from corrosion will disappear. I have experienced J. B.'s trouble and I sympathize with him. It is very annoying and hard to overcome.

The Pyramid paint I mentioned can be obtained from the Pyramid Paint Co., Philadelphia, Pa.

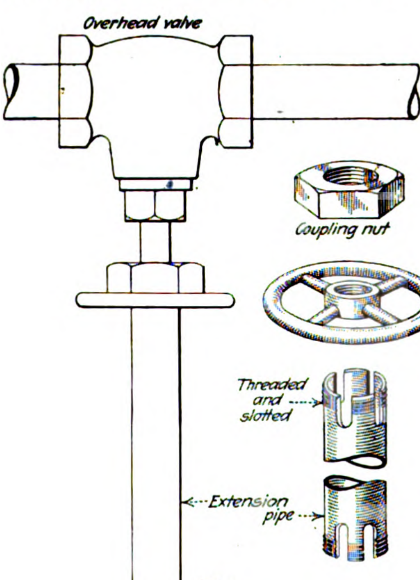
Dallas, Tex. F. J. H. KRAUSE.

Building Maintenance and Plant Safety

The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Simple Extension for Lengthening the Valve Stem for Convenience in Control

PRACTICALLY every operating man has found instances where those responsible for the construction of the plant have placed valves and other similar equipment in places difficult of access or almost unbearable because of the heat or wet, and in some instances even in locations dangerous because of proximity to moving parts of machinery. Sometimes these difficulties may be overcome by building platforms or using ladders. To change the location of such a valve is often expensive and may require the temporary shutting down of a section or all of a plant. Even though these valves may be operated infrequently a delay incidental to an emergency operation, because of the difficulty of access, may be serious.



With this simple attachment an extension handwheel can be placed on valves which are located in places difficult of access.

One way of operating such valves is by means of the easily-constructed extension handwheel shown in the accompanying sketch. This extension is made from a length of pipe, threaded and slotted on each end, as shown in the detailed drawing, to go over the spokes of the handwheels. The extension pipe is secured, both to the valve handwheel and the added handwheel, with two coupling nuts. In case these nuts are not available, two pipe caps can be used but the one to be placed at the valve must be drilled out to go over the stem.

This is an easily-made fixture which it is possible to construct in a short time, in almost any shop, without any special facilities other than pipe tools. With an extension such as this a valve may be operated from either side of a wall.

Washington, D. C. G. A. LUERS.

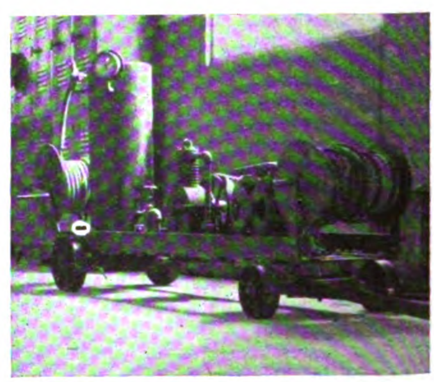
Constructing a Portable Air Compressor for Supplying Air in Isolated Locations

EXTENDING the piping system so as to place compressed air outlets convenient to all motors in and around a large industrial plant usually means a prohibitively heavy expenditure, unless there are other uses for the air at those locations. Also, where the compressor is supplying various tools, suction boxes and other equipment, an extra supply of air is not always available when needed for blowing out foreign material from motors. It often happens, too, that the general air supply is rich in moisture which may do as much harm to the motors as the dust would, if it were allowed to remain.

An economical portable compressor, as shown in the accompanying illustration, was built by the writer and has given entire satisfaction. A small compressor, originally used on the sprinkler system, was mounted on the truck which was built for the purpose, and connected to a tank made from a 3-ft. length of 12-in. heavy wrought-iron pipe, the two ends of which were sheeted and welded. This tank withstood a pressure of 150 lb., and was provided with a gage and pop valve set at 120 lb.

The motor used is a spare 5-hp., 550-volt, three-phase, 1,800 r.p.m. induction motor which, while about three times too large for the compressor, did not add to the cost of the outfit as it could be used in other places and also serve as a spare.

Two reels were mounted on the truck, one with 150 ft. of ½-in. hose and the other 250 ft. of four-conductor cable. The ends of the cable were fitted with universal test clips so that 550 volts could be obtained easily from any service station around the plant. This gives a working range of practically the whole plant and yard as compressed air can be supplied at practically 400 ft. from the electrical power outlet.



This portable compressor is used to supply compressed air in isolated locations.

Often, all parts of a plant are not provided with compressed air pipes. This portable compressor was made up of miscellaneous spare equipment at one plant and provided with 250 ft. of cable and 150 ft. of air hose which would give it a range of almost 400 ft., from any power outlet.

When this equipment is being used to blow out equipment two men can easily handle the outfit and do more work than is possible with the air outlet system. H. E. STAFFORD.

Electrical Engineer,
Port Arthur, Ontario, Canada.

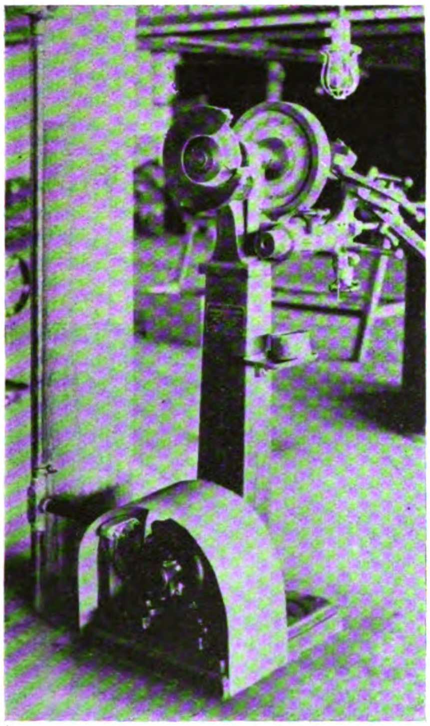
[EDITOR'S NOTE: To prevent the force of the blast from rupturing the insulation, it might be well to use some method of reducing the pressure before applying it directly to motors. If blowing out motors is the only use for this portable outfit, a hand blower with extension cord might be used much more economically. Other applications, however, of a portable compressor of this sort might be for operating drills, hammers or other tools in isolated locations or other places which are not piped with air. It could also be used for general cleaning or with a paint spray.]

Inexpensive Guard for Motor of Direct-Driven Grinder

AN UNUSUALLY simple but flexible motor guard for a vertical grinder unit was made up in a Massachusetts factory by bending a piece of sheet iron over the top of the motor, as shown in the illustration. A slot in the side of the guard next to the adjacent column permits the entrance of the conduit feed line. The guard is held in place by screwing it to the wooden base on which the grinder is mounted. This guard is strong, but easily removed when necessary and, as will be seen, gives ample protection to the motor and wiring.

This shield not only protects the motor from water dripping but also prevents abrasive material from getting into the bearings. Another possible source of trouble guarded against is particles of steel getting into the windings and causing grounds or shorts.

Boston, Mass. H. S. KNOWLTON.



A piece of sheet metal was bent into the form of a semi-circle and fastened in place over the motor by screwing it into the wooden base on which the grinder is mounted.

Procedure for Refinishing of Heavy Machinery

IT IS often necessary or desirable to refinish large generators, motors, engines and other equipment. Refinishing is not a particularly difficult process, but unless certain precautions are observed and the work as a whole carefully done the results are likely to be disappointing. The following instructions, which we have used with good results, may therefore be of interest to the readers of INDUSTRIAL ENGINEER.

(1) *Finishing a Machine Completely.*—When putting an entire new finish on a machine or piece of apparatus in a plant, the following procedure shall apply:

(*a*) Scrape the machine thoroughly to remove all traces of the old filler and enamel. Wash the machine with gasoline, or carbon tetrachloride, if available, to remove all traces of oil. The surface of the ironwork must be entirely free from oil before the filler is applied.

(*b*) Apply one coat of brush filler. This filler is prepared by thinning Degraco Filler Paste Color No. 52, grey, to a brushing consistency with turpentine. Allow one hour for this coat to dry.

(*c*) Fill in all rough spots and holes using the filler as it comes from the can. Before proceeding further the machine should be allowed to dry at least twelve hours.

(*d*) Reduce some of the filler to a semi-paste with turpentine and smooth out all irregularities with a knife. After getting the surface as smooth as possible follow up immediately with a coat of brush filler as under (*b*). It is best to knife a small area, say a square foot or two, and then go over this spot with the brush filler, rather than knife the whole machine before brushing it over.

(*e*) Give a final complete coat of brush filler and allow to dry twelve hours.

(*f*) Rub down very carefully with sandpaper starting with No. 1 and finishing with No. 00. Procure a piece of smooth soft leather and finish the filler down to a perfectly smooth surface.

(*g*) Before proceeding to apply the machine enamel, paint the armature, field coils, armature spider, pole faces, cables, etc., with Westinghouse Air Drying Insulator Varnish.

(*h*) Apply a coat of Degraco Machinery Enamel Color No. 118, yellow ochre, and allow time to dry.

(*i*) When thoroughly dry go over the machine carefully and note any spots that are not perfectly smooth and glossy. Work these down with No. 00 sandpaper, being careful not to remove the enamel entirely.

(*j*) Apply final coat of enamel to the machine, being careful to brush out smoothly and evenly leaving no brush or finger marks. While putting on this coat and during the time it is drying, be very careful not to allow dust to settle on the surface. Avoid all sweeping and if possible keep the room closed. As a precaution it is a good plan to make a screen to put over and around the machine, where possible.

(*k*) During the whole process of finishing do not permit any oil to get on the machine as it will prevent the proper adherence of the filler and enamel.

(2) *Retouching Finish on a Machine.*—When retouching the finish on a machine that has been re-assembled after repairs or on which the finish is damaged from other causes, the following procedure shall apply:

(*a*) Sandpaper with No. 1 paper the parts affected, to remove all loose or cracked particles of filler or enamel.

(*b*) Brush or knife in filler according to the nature of the damage, giving two coats and allowing about ten minutes between them.

(*c*) When thoroughly dry smooth down carefully and sandpaper starting with No. 1 and finishing with No. 00. Give a final rub down with leather.

(*d*) Apply a coat of enamel and let dry over night.

(*e*) Apply final coat of enamel observing precautions noted above under (1) *k*.

By the use of these instructions it is easy to standardize the refinishing of machinery. I have found that if the operations outlined are carefully performed a very satisfactory finish will be obtained. FREDERICK KRUG.

Comerio Falls,
Bayamon, Porto Rico.

Effective Method of Cleaning Windows and Skylights

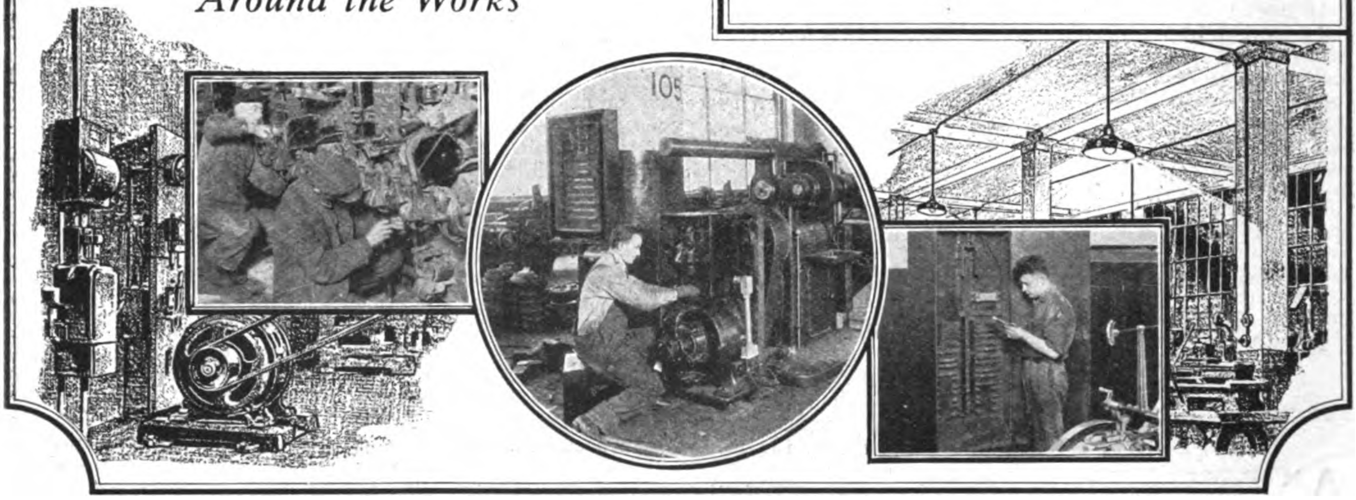
SKYLIGHTS and windows are provided to enable workers to take advantage of natural daylight but if the windows are neglected and grime and dirt allowed to cover the glass, much of its effectiveness is lost, especially if rough or translucent glass is used. Dirty windows can easily make it necessary to supply artificial illumination an hour or two extra each day and often all day, when it might not otherwise be necessary.

The big difficulty lies in getting a solution which will soften this grime without requiring too much labor and time or damaging the steel sash. After numerous experiments with various home-made cleaning compounds, some of which contained acid and destroyed the metal sash, while very few of them cleaned satisfactorily, the Economy Engineering Co., Chicago, tried out a liquid cleaner sold under the trade name of Glow-Brite, which not only cleaned the glass quickly and well but did not affect the metal sash. It is only necessary to rub this cleaner on the glass to dissolve the dirt and then flush it off with clean water. In this plant, part of the offices and the two-story assembly floor near the center of the building depend upon skylights for natural illumination. For this reason it is essential that the skylights be clean enough to really provide some light and the use of this cleaner has solved what was formerly a troublesome problem.

Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Novel Method of Finding Ground In Generator Armature

IN A PLANT where I was employed, a steam-pipe split one morning just before starting time. The break occurred above the outboard bearing of one of the 150-kw., d.c., engine-type generators and before the steam could be shut off at the boilers, the engine room was completely filled with steam and, of course, everything was well soaked.

As soon as the broken pipe had been replaced, all of the machines were started up and run slowly for several hours, in order to dry them out. The generator nearest the break apparently got the worst of it, as almost all of the paint was washed off. However, it was put on the line the following day and seemed to carry the load as well as usual, but after two days' run, it was noticed that there was a ground on that machine.

The usual tests were made, but the ground could not be located by our crew; so an expert electrician was called in. He decided that the machine would have to be dismantled and the armature rewound, estimating the probable cost to be between $300 and $400. The chief did not believe that rewinding was necessary; so with our own crew the trimmings were removed from the machine and at the chief's direction the armature was turned until a certain side was up. The top half of the field was pushed over with screw-jacks towards the fly-wheel and as the ceiling of the engine room was so low that there was no room to use chain-blocks, timber was used to block it up from the wheel-pit.

Three of the bands were removed from the armature and the commutator leads raised from the front end of one of the slots. The insulation was found to be burned through and the bare wire was in contact with the armature core. After reinsulating the wires with rubber tape and shellac and painting with asphaltum paint, they were replaced.

The bands were wound on by hand, as it was impossible to run the machine on account of the blocking through the flywheel, but the job was accomplished by soldering each turn as it was drawn tight. The field was then pushed back in place and bolted, and the brush-holder rigging reassembled. Upon starting up, the generator ran as well as ever and the whole cost of the repairs did not exceed $10. On being asked how he located the trouble so quickly, the chief replied that he smelled the burned insulation at that particular slot in the armature.

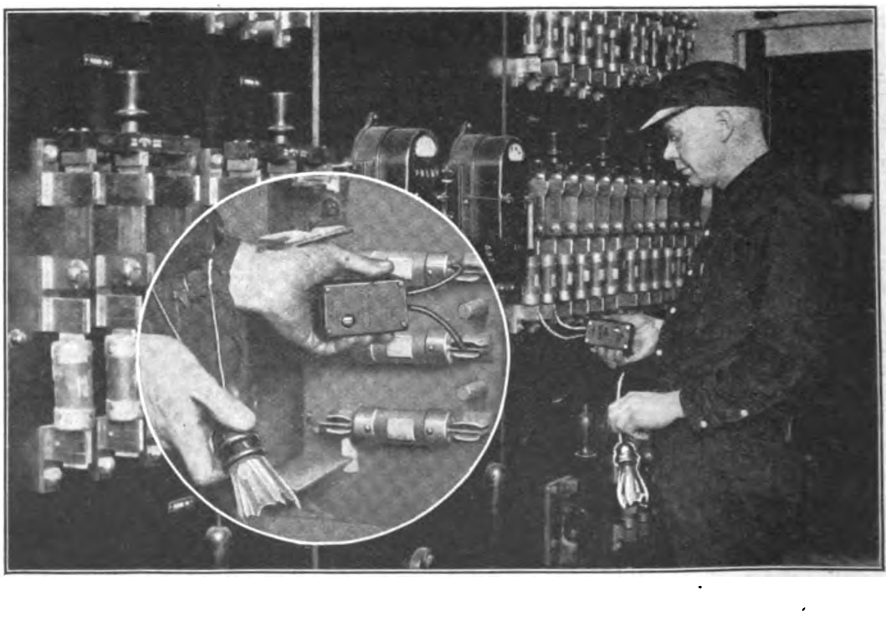
Utica, N. Y. M. M. BROWN.

Methods Employed for Locating Open Circuits

ONE of the most frequent causes of delay charged to the electrical department are open circuits due to disconnected wires, blown fuses, loose connections and the like. There are several ways of locating the open circuit causing the trouble. Probably the most common method is by guessing. The trouble man hurries around pulling wires, tightening bolts, changing fuses and the like, loses a lot of time and perhaps finds the trouble only by accident. A method often used to determine whether a fuse is blown is to remove it from its clips and shake it. If it rattles it is considered "blown" or "open."

A more reliable way of locating open or blown fuses is to use a magneto. However, in this case it is best to have the power off the line. This is not always convenient. Moreover, the magneto, since it is heavy and cumbersome, is not always at hand when the trouble occurs.

A common method involves the use of a test lamp. This is open to the objection that if several voltages are in use in the plant, it is necessary to carry several different lamps; otherwise, if a low-voltage lamp is used on a 440-volt circuit, it will blow up and may



Method of using tester for locating blown fuses.

The leads of the tester are placed across the fuse clips. If the fuses are intact a small lamp within the tester lights up. The broken lamp shown is not a part of the tester.

injure the person doing the testing. Also the lamp socket and lamp are often broken, thus adding extra expense and causing a delay until another lamp is obtained.

Another method is to use a fuse and circuit tester such as made by the Electric Tester Mfg. & Sales Corp., Portland, Ore., and shown in the accompanying illustration. This tester is small and easily carried in the inspector's pocket; hence, it is always at hand. It can be used on alternating or direct-current circuits from 110 to 600 volts. For voltages lower than 600 volts, a push button switch shorts out some of the resistance in series with the lamp. If the push button is accidentally pushed while the tester is on a 600-volt circuit no harm will be done. The lamp is enclosed in the tester and hence is not readily broken as is the case with the open lamp and lamp socket.

Portland, Ore. L. D. JOHNSON.

Distributing Outgoing Feeders From Wire Tower

IN ANY plant which has an extensive electrical system, conductors either in conduit or in open wiring, passing through walls and across the ceilings in the various departments often take up useful space. When many lines are run they have, of course, a more sightly appearance if they are arranged as neatly and compactly as possible, than when loose and much spread out.

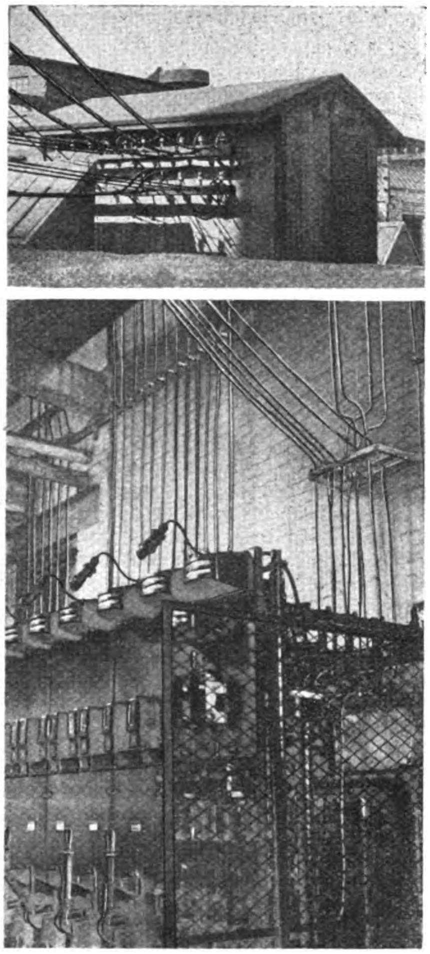
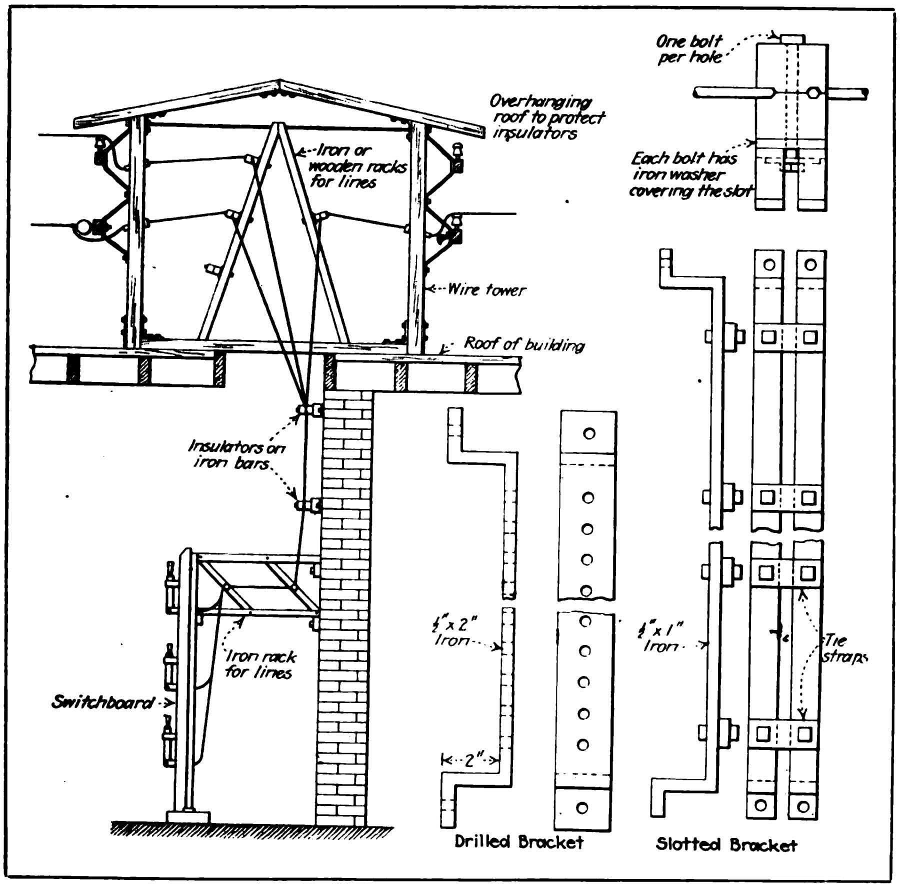


Fig. 1—Wire tower on roof of large industrial plant and, below, method of running feeders from switchboard to tower.

Fig. 2—Details of wire tower and at the right, drilled and slotted brackets for supporting porcelain cleats.



If large cables are run across the ceiling and through walls much space is needed for large cleats, strain insulators, brackets and so on; besides it is almost impossible to draw such conductors tight, and hard to keep them that way. Also inside wire must be rubber covered and if it is in conduit another expense is added, while if the conductors were run outside weather-proof wire could be used at less expense.

A wire tower erected directly over the switchboard, or nearly so, affords a neat and inexpensive method of getting feeders out of the way. Then the lines can be carried up the wall into the tower and from thence to the various buildings and departments by long spans over roofs or through alleys and over yards, being supported by strong arms bolted to the corners of buildings or on iron pipe racks on the roof. This scheme does away with carrying a multiplicity of conductors through walls and when the conductors leading upwards from the switchboard are uniformly spaced from 3 in. to 6 in. apart and drawn tightly, they are not an eyesore. Fig. 1 shows the general arrangement of the conductors leading from the switchboard to the tower, as well as a view of the wire tower. Details of the construction of the tower are given in Fig. 2.

White, slow-burning insulated wire can be used from the switchboard to the tower and there spliced to either weather-proof or rubber-covered wire which is used for the outside run.

The lines above the switchboard should be so arranged on 1-wire porcelain cleats bolted to iron brackets that they will all be properly spaced and yet quite compact, and should turn in at the top of the board to allow head-room for workers behind the board later on. Where many lines are carried up the wall, brackets can be used to accommodate one tier in front of another with at least 6 in. between.

If any lines are to be transposed or crossed to a certain point, the crossing should be done either behind the board or up in the wire tower, and not where it would be unsightly, as on the wall. Iron brackets on the wall look much neater than wooden ones, and should be painted black or white.

It is advisable to use a fair-sized cleat, such as No. 2 or No. 2½ for as many conductors as possible before changing to other sizes. The brackets on which the cleats are mounted may be either drilled or slotted. Details of both the slotted and the drilled type are given in Fig. 2.

Up in the tower the wire should be carried on an iron rack, provided with cross arms and cleats, which straddles the opening in the roof. Here the lines may be turned in almost any direction so that they will emerge at the proper arm and pins fastened to the outside of the tower. As they leave the tower from a supporting rack outside, the lines should be spaced at least 12 in. apart. The small conductors may be tied to pins; the large conductors should be fastened to the arms by strain insulators. The tower must, of course, be made strong enough to withstand any strain imposed by the lines.

New Britain, Conn. H. S. RICH.

Conductors With Varnished-Cambric Insulation Can Carry More Current

RECENT observations in the field indicate that varnished cambric insulated conductors are coming into wider and wider use in electrified industrial plants of the most progressive type. This is because, in part, varnished cambric is not damaged by heat as easily as is rubber. As a result, according to the code of the National Board of Fire Underwriters, varnished-cambric-insulated wires and cables may carry approximately 20 per cent more current than those insulated with rubber compound. This means, of course, a saving in copper. Usually the next smaller size of varnished-cambric-insulated wire may be used instead of a certain size of rubber-covered. However, the varnished cambric may be used in sizes smaller than No. 6 only by special permission of the Fire Underwriters.

The code of The Associated Factory Mutual Fire Insurance Company, an organization which operates extensively in the Eastern part of the country, allows the larger sizes of varnished-cambric-insulated conductors to carry upwards of 40 per cent more current than is allowed by the National Electrical Code for rubber-covered conductors of the same size. This is shown in the accompanying table, which gives the carrying capacity allowed by the National Electrical Code for conductors with rubber and other classes of insulation, and the corresponding carrying capacity allowed by the code of The Associated Factory Mutual Fire Insurance Company for varnished-cambric-insulated conductors.

There are also other advantages. Varnished cambric is not so easily damaged by corona as is rubber, so that where current is distributed in large plants at the primary voltage it is preferable, as corona may be present in sufficient amount to damage rubber even if it is not visible to the eye. Of course, varnished cambric is almost universally used in power houses for the high-voltage, alternating-current, single-conductor leads, when paper insulation is undesirable on account of the inductive effect of the lead sheath necessary to protect paper against moisture.

This brings up another advantage of varnished-cambric insulation, which is, that it is reasonably impervious to moisture. While conductors insulated with this material cannot, as a rule, withstand submersion in water for long periods, unless sheathed in lead, they are not injured by a considerable amount of moisture in the air. This immunity to harm from a reasonable degree of moisture means that extreme care and skill are not required in splicing. Therefore these cables are desirable for use under circumstances where expert splicers are not readily secured. Of course, for underground sections between buildings the cables should be covered with a lead sheath.

New Canaan, Conn. F. A. WESTBROOK.

Allowable Carrying Capacities of Wires With Different Classes of Insulation

B & S Gage	Diam. of Solid Wires in Mils.*	Area in Circ. Mils.	National Electric Code: Rubber Insulation, Amperes	National Electric Code: Other Insulation, Amperes	National Electric Code: Varn. Cloth Insulation, Amperes	Factory Mutual Code: Varn. Cloth Insulation, Amperes
18	40.3	1,624	3	5	.....	.....
16	50.8	2,583	6	10	.....	.....
14	64.1	4,107	15	20	18	.....
12	80.8	6,530	20	25	25	.....
10	101.9	10,380	25	30	30	.....
8	128.5	16,510	35	50	40	.....
6	162.0	26,250	50	70	60	50
5	181.9	33,100	55	80	65	.....
4	204.3	41,740	70	90	85	80
3	229.4	52,630	80	100	95	100
2	257.6	66,370	90	125	110	120
1	289.3	83,690	100	150	120	150
0	325.0	105,500	125	200	150	175
00	364.8	133,100	150	225	180	200
000	409.6	167,800	175	275	210	250
....	.....	200,000	200	300	240	275
0000	460.0	211,600	225	325	270	.....
....	.....	250,000	250	350	300	.....
....	.....	300,000	275	400	330	375
....	.....	350,000	300	450	360	.....
....	.....	400,000	325	500	390	450
....	.....	500,000	400	600	480	550
....	.....	600,000	450	680	540	630
....	.....	700,000	500	760	600	720
....	.....	800,000	550	840	660	780
....	.....	900,000	600	920	720	.....
....	.....	1,000,000	650	1,000	780	900
....	.....	1,100,000	690	1,080	830	.....
....	.....	1,200,000	730	1,150	880	1,030
....	.....	1,300,000	770	1,220	920	.....
....	.....	1,400,000	810	1,290	970	1,150
....	.....	1,500,000	850	1,360	1,020	.....
....	.....	1,600,000	890	1,430	1,070	1,250
....	.....	1,700,000	930	1,490	1,120	.....
....	.....	1,800,000	970	1,550	1,160	1,320
....	.....	1,900,000	1,010	1,610	1,210	.....
....	.....	2,000,000	1,050	1,670	1,260	1,400

*1 mil = 0.001 in.

NOTE—Varnished cloth insulated wires smaller than No. 6 may be used only by special permission of the Fire Underwriters.

Quick Method of Synchronizing Generators After Excitation Failure

IN THE March issue of INDUSTRIAL ENGINEER, page 148, J. H. Gallant described under the above heading a method of synchronizing generators which is quite practicable and has been used by the writer on a number of occasions. In a power station where four 5000-kva. units were installed excitation was lost through the flashing-over of a single exciter unit which supplied the four units. The generators and exciter were all waterwheel driven. The restoration of service was handled as follows: (1) The low-tension oil circuit breakers on the low-voltage side of the step-up transformers were opened. (2) The resistance was then cut into the exciter field and the exciter breaker closed. (3) The generator field switches and rheostats as well as the main generator oil circuit breakers not having been touched, it was only necessary to bring the exciter voltage up to normal. (4) As the exciter voltage rose the generator ammeter showed when the machine pulled into synchronism and slight adjustments of the field rheostat reduced the cross currents to a minimum. (5) Almost simultaneously with the "pulling in" of the generators, the step-up transformer breakers were closed and service was restored.

So far as damage to the generators is concerned, the final answer to this question should be given by the designer of the unit, but so far as the writer was able to observe, no excessive currents were indicated on the main generator ammeter.

For the case considered in the writer's experience, the speed regulation of the turbines was very good, in fact within 10 per cent. This particular feature would aid considerably in bringing the units into synchronism again after they had dropped out.

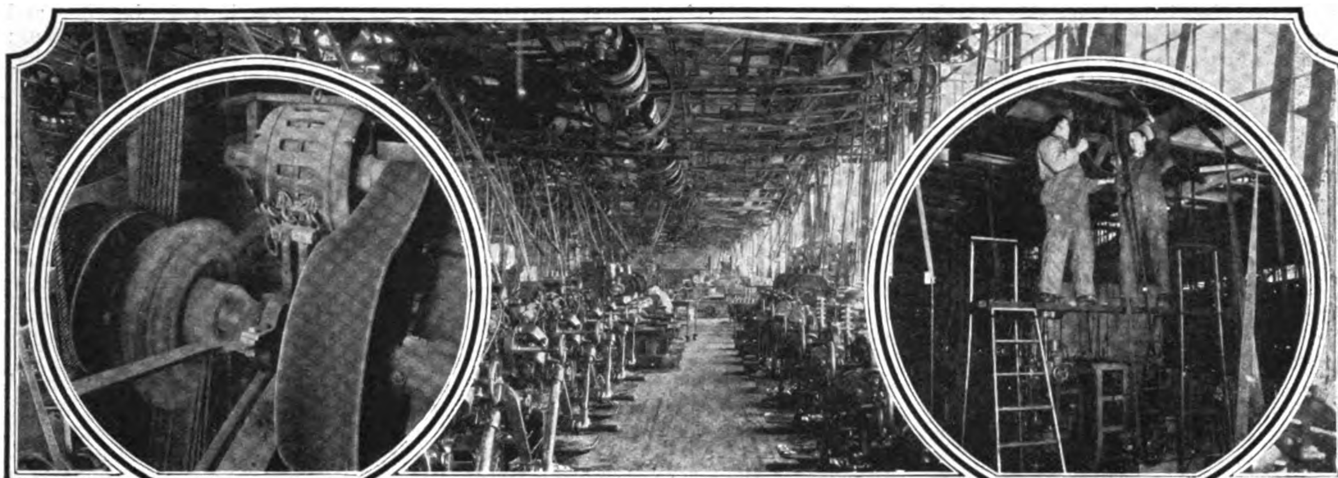
It was necessary to use this method of synchronizing three times within a period of six months and so far as we could determine from a superficial examination of the generators and their performance in general for two years afterward, there were to be found no indications of any permanent trouble or defects.

It may be of interest to note that in starting up a large compound steam turbine unit made up of one high-pressure and two low-pressure units, the three oil circuit breakers are first closed and a low field current is put on the high-pressure unit. Steam is then admitted to the high-pressure unit and as it begins to rotate, the two low-pressure units are brought up to synchronism as motors. This method of starting the unit obviates the necessity of synchronizing the combined unit for more than one generator.

Mr. Gallant's estimate of the time saved in putting the seven generators into service seems to the writer to be very conservative. Under more unfavorable conditions 30 min. might easily be required to do this.

C. OTTO VON DANNENBERG.

The J. G. White Engineering Corp., New York, N. Y.



Mechanical Maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Three Additional Comments of Manufacturers on Possible Improvements in Bearing Service

BEGINNING on page 264 of the June issue of INDUSTRIAL ENGINEER representatives of several bearing manufacturers told under the above heading, what has been done in the way of making improvements in bearing operation, with some of the practical points to consider when installing sleeve and anti-friction bearings in equipment. Here are three additional comments which came in too late to be included with the others.

John Taylor, SKF Industries, Inc., New York, N. Y.: As we see the bearing problem it naturally resolves itself into three parts: (1) The selection of the proper bearing type and size for the work to be done. (2) The installation of the bearing so selected in a correct manner, which will insure the user getting out of it its best performance and that measure of satisfaction to which he is entitled. (3) The correct treatment of the bearing by the user after the installation has been made.

In each of these headings is a situation which, it is evident, requires that the bearing manufacturer receive the co-operation of the machine builder, for selection of the bearing type and size must be based on a set of conditions which are submitted to the ball bearing engineer, but which he has no part in collecting. With his background of experience along similar lines and knowledge of previous successes (and failures too), he can from the facts given him determine the proper bearing type and size to employ. He will also adjust his housing design to form a harmonious part of the rest of the machine, but too frequently his work is circumscribed by limitations which are a heritage of previous plain bearing designs.

Granted that the right bearing has been selected and properly mounted, it still remains for the machine user to see that it has such attention as will insure its standing up to its work. This attention, although infrequent, is nevertheless essential. The very fact that lubrication periods are so far apart makes it easier to forget them altogether, and just as important as seeing that the bearing has an ample amount of lubricant within its housing, is the duty of seeing that the housing is kept clear of moisture and foreign material such as dirt or abrasive matter of all kinds.

If this trinity of essentials, Selection, Mounting and Maintenance, are all properly allowed for they will result in a harmonious whole.

Mr. Donaldson, Engineer, The Bunting Brass and Bronze Co., Toledo, Ohio. Of the many types of journal bearings brought forth by aid of the dividers and the T-square, the sleeve bearing is the patriarch and carries its years well. In every case where successful service has not been obtained the failure can be traced to one or more of the causes to be specifically mentioned later, and is in no way attributable to error in the fundamental idea involved in the sleeve bearing.

Mechanics who favor the sleeve bearing give clear reasons for their faith, among them being its ability to take punishment with a minimum of deterioration. Simplicity is another argument in its favor. Should necessity insist the sleeve may, when badly worn, be bored out and babbitt metal poured in to fit the journal, preventing a lengthy shut-down until replacements can be obtained. When the new sleeve bearings are at hand the makeshift can be relieved from duty. Availability is another strong argument for the sleeve bearing. In machine designing it is often necessary to have the rotating member enlarged on both sides of the portion allowed for the bearing, notably in case of a crank shaft. It is rather a difficult feat of engineering to use any other type of bearing, but the split sleeve bearing makes light of this difficulty.

The sleeve bearing properly designed and made, properly installed and properly lubricated, may be trusted to do its duty properly. On these points pivot its success or failure. If they are attained and maintained the bearing will last indefinitely. Whether the life of the sleeve bearing shall be long and smooth or short and turbulent, is determined by its progenitor—the mechanical engineer. His is the duty of accurately ascertaining the maximum load to be carried by the bearing. Included in his calculations is the amount of freedom to be allowed—the difference in diameter between the journal and the bore of the sleeve. The space he allots should provide room for a film of oil sufficiently heavy to sustain the load put on it by the journal without becoming crushed or broken. Should this happen the journal and sleeve will be in direct rubbing contact, friction increases, heat is generated and the viscosity of the new oil supplied to the bearing is destroyed. The result, if a remedy is not applied, will no doubt be stoppage of the machine and in extreme cases twisting off of the shaft.

There is little to be said about the making of a sleeve bearing that is not included in the duty of the designer. When the bearing is made of cast metal the designer determines its composition, he establishes the size of bore, number and position of oil holes and form of oil grooves. The oil holes he indicates on that side of the bearing opposite to the load-receiving side. He makes the oil grooves of generous proportions, but few in number. Close to each end of the bearing he puts annular grooves. The annular grooves prevent the flow

of oil on the journal outside of the bearing and have one or more holes drilled in the lower side to allow the used oil free return to the oil reservoir when oiler rings are used. The distributing or lateral grooves connect the oil holes with the annular grooves, and it is their mission to convey the oil along the bearing, allowing the journal to cover itself with a film of oil.

One style of conveyor groove that has given general satisfaction is curved in form, the curved groove cutting through the center of the oil holes and the ends pointing in the direction of travel of the journal, allowing the oil, as we may say, to run down hill. In the case of a rapidly revolving journal this design of groove may become an oil pump and flood the bearing, in which event the curve is reversed. In no instance should the conveyor grooves extend below the center of the bearing,because any grooves on the load side of the sleeve would tend to disrupt the oil film and also lessen the pressure area of the load surface.

Installing a sleeve bearing should not be intrusted to the millwright's apprentice. To obtain desired results the shaft must be straight and the bearings in perfect alignment; otherwise the load intended for the full area of the bearing will be thrust on only a small portion of that area.

The proper lubrication of the bearing is the final consideration and, like woman's work, it is never finished—it must be continually repeated. Drop cups or oiling rings are considered two of the best methods of insuring a constant supply of lubricant. The capillary attraction of wool as an oil-delivering agency is well thought of by some lubrication experts. But no matter by what method the oil reaches the bearing, the vital point is to get it there—plenty, but not too much.

R. Pruger. Power Engineering Department, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.: Wherever machinery is found, bearings and shafts are essentials; and wherever machinery is used, human intelligence must be applied to keep things running smoothly. There are cases where bearing troubles form a large percentage of the yearly repair bills, and others where this item is rather a small fraction, and sometimes the smallest fraction, of the total upkeep expense. Why?

Since such conditions exist, there must be an answer. The motor user is probably the one most interested in finding the right answer to this question, since there are places which not only make it difficult to get at the motor for repairs, but where a continuance of production is vital. Yet, it is surprising to note the large number of bearing failures and the large number of motor users who accept such failures as a matter of course. There is no more reason why motor bearings should give trouble due to oil leakage than why other defects should be tolerated.

To accomplish this, it is first of all necessary to find out the reason why failure occurs. To change over to some other type of a not-yet-established reputation is hardly good policy, particularly where such a change may involve considerable extra expense.

I feel sure that ninety-nine out of a hundred engineers and operators have not seriously made a study of their troubles; they hear of something else, and at once jump to the conclusion that they must change over in order to remedy their troubles.

First, there is the matter of oil leakage. This is serious for not only does it mean the waste of a large amount of lubricant, but, what is worse, it means that the escaping lubricant enters the motor, destroys the windings, short circuits the commutator, and creates various troubles. In spite of this, there are many plants where the oiler is instructed to see to it that the housings are kept well filled and accordingly, oil is poured into the bearings once or oftener every day. Of course the oil level must be maintained—no doubt about that—but why not issue instructions to make a report of such cases, and then find out just why a certain bearing needs replenishing of lubricant so frequently?

It has been noticed not infrequently that oilers pay little attention to the proper oil level; the oil can is used freely, and while the stream is flowing, attention is not always concentrated where it should be—that is, on the overflow plug. In one case it was noticed that the overflow gage, a drilled hole on the side of the housing, was completely stopped up with dirt and sawdust; and bearing was given a generous supply of oil until it ran into the motor through the clearance in the housing bore on the inside end. A toothpick applied to these overflow gage holes had the effect of creating considerable overflow, getting the oil level back to where it belonged. In another instance oil-hole covers, supposed to be firmly held down by screws, had been loosened to permit of oiling through the oil-ring slot in the top of the housing instead of making use of the proper filling hole which was a little slower, of course. Air was thus admitted freely to the bearing and the suction on the inside end of the housing set up by the blower drew air currents through the housing, carrying oil vapor and streams of oil.

Bear in mind that one of the principal troubles of oil leakage is the fact that the bearing is not held air tight; if the air gets in, the oil will get out. The "outlet" itself, which is the opening around the shaft (usually 1/16 in.) is not harmful, if the inlet is closed; and that means the oil-ring slot, peep hole, and other such openings.

The bearing should have annular grooves at the motor end, or better still, at each end, and one or two holes at the bottom of the groove; this will get rid of the oil after it has done its work in the bearing, and relieve the oil thrower. Also, look to the oil thrower, and where it throws the oil, and where the oil so thrown off will flow. If it is allowed to get back on the shaft beyond the thrower, and thus escape, this defect can be easily overcome by a little ingenuity. Keep your bearings clean; change the oil shortly after a new motor has been put into operation. Core sand may have been missed by the air blast, in which event it will soften, get into the bearing, and wear it out. Dust-proof the bearings; if you don't, dirt will get in, and that means wear. It is not to be wondered at that bearings fail in such places as foundries, where the air is cloudy with fine sand floating around.

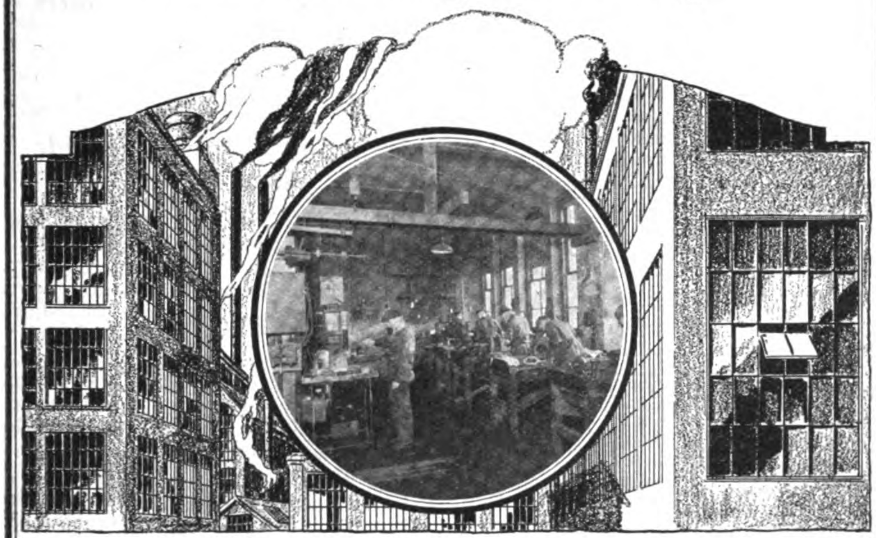
Don't put your gear or pulley away from the housing, when it might just as well be close to it, because the shaft deflection will concentrate pressure on one end of the bearing, and cause "galling" That seems plain, and yet I recall a case where this very thing happened; the motor being used to run a tight and loose pulley of some machine, the tight pulley drive was arranged so as to be farthest from the motor bearing; result, trouble every few weeks. Now, there is another case, which may be doubted, but which is a fact: In one plant, it was found necessary to rebabbitt the bearings, and in this case the repair shop was located some distance from the motor. The repair man, in order not to have the babbitt cool, superheated the metal, carried it in the ladle to the motor and poured the babbitt around the shaft and, to make matters still worse, this treatment was accorded a lead-base babbitt.

Rebabbitting, if it must be done, should be done correctly; no trouble to find out how to do it, but lots of trouble if you don't If you can not take the time to stop the motor long enough to take out the bearing for rebabbitting, get a spare one. Babbitt metal, particularly lead-base babbitt, must be handled very carefully at certain temperatures. You should make allowance for boring out, and then remember to provide for proper running clearance, and see to it that the oil grooves are cut, and cut correctly; they should connect up with the oil-ring slot and curve downward, since the flow of oil is in that direction. A groove along the line of pressure for horizontal belt pull is not the best form, since it allows the oil to escape when it should hold the pressure and form a film. Provide amply for a "relieve" to permit the oil to get under the shaft in a wedge shape; this will reduce bearing temperature, since it means a perfect film, carrying away the heat. Where the load is mostly downward, such a relief can be made for an angle of 20 deg. from the horizontal center line, merging gradually into the bore proper.

All these points are simple ones, obvious, and if followed will have good results. There are motors running with such bearings in dirty and dusty places, with no attention for months. As a matter of fact, I know of some cases where oil was put in when starting up, and no further attention was given or required, and that was a year ago.

So don't be hasty in forming an opinion of a thing which did not give satisfaction at once, until you know the reason why! And after you have found out, then figure out why you cannot overcome it if the other fellow can, and what it would cost you trying something new, of which you know no more than what some enthusiast has told you. The man who says "it can't be done" of a thing which "has been done," has never really tried to do it.

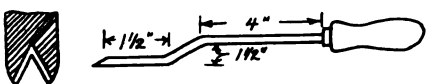
In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Easily-Made Tool for Trimming Slot Insulation

FOR TRIMMING the insulation in armature and stator slots we use a simple, easily-made tool which has given very satisfactory results. As will be seen from the accompanying illustration, the tool was made from an old, thin file. The temper was drawn and



A tool like this, made from an old file, will save time in cutting slot insulation.

the file then ground down until it was about ½ in. wide and ⅛ in. thick, after which it was bent to the form shown. The end was then filed to a V-shape and beveled to give a sharp cutting edge.

In use, the insulation in the slot is trimmed off flush with the iron by pushing the sharp edge of the V-shaped end along the top of the slot, with the paper between the sides of the V. The paper is cut smoothly and easily and we find that the use of this tool has reduced considerably the time required to do the job by other methods.

Peoria, Ill. GEORGE RINGNESS.

How to Make Motor-Driven Saw for Bench Use

FOR cutting thin steel or brass sheets, fibre or insulating materials and so on, a large shop has made up and uses a number of simple jig saws, the details of which are given in the illustration.

The blade holder is a forged steel part with hanger and tightener for keeping the blade taut. A 12-in. blade can be used to advantage, as this is a standard length.

The back of the holder is provided with a T-edge as a guide and terminates at the lower end in a link connection for the rod which connects it to the driving pulley. A slotted bracket for supporting the saw vertically above the bench has a T-slot in which the blade holder moves and thus serves as a guide. According to the facilities available, brackets may be made of cast iron, forged steel or brass.

A simple strap bracket mounted under the bench supports on a suitable bearing a small pulley fitted with an eccentric pivot. A short link or rod on the pivot connects the driving pulley to the link at the bottom of the blade holder. The saw is driven by a ¼- or ½-hp. motor which is also mounted underneath the bench and belted to the saw pulley by a flat belt.

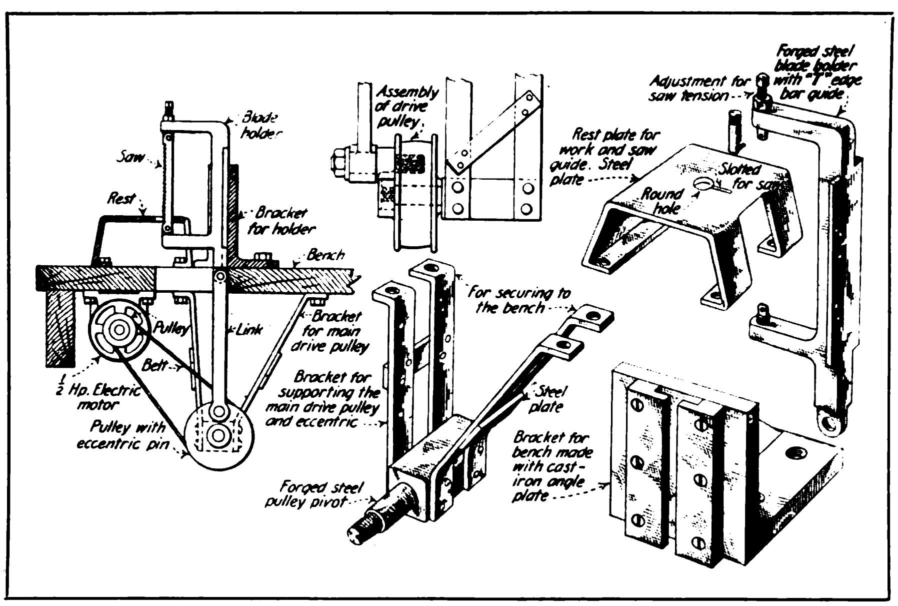
The rest plate for the work is made from sheet steel or boiler plate which is bent to shape and the saw opening made as shown. A drilled hole clears the chips, while the narrow slot guides the blade. Dimensions are not given in the illustration as they are not of particular importance and may be varied to suit the conditions or materials available.

In operation, the saw blade travels up and down at a high rate of speed; the work is supported on the rest plate and brought in contact with the saw which slots or cuts it easily and accurately. When cutting out intricate designs, the sheets are marked in outline from a master part and can be cut out almost as rapidly as they can be fed against the blade.

When a shop has much work of this character, this power-driven saw will be found to be a very useful tool as it will save a great deal of time and labor, enabling the workman to do a neat and accurate job in much less time than would be possible by the use of other methods.

Washington, D. C. G. A. LUERS.

Details of construction of motor-driven jig saw which can be mounted on the work-bench.



High-Voltage Test Set for Use in the Repair Shop

ARMATURES, after they have been rewound, should be subjected to a high-voltage test from the copper to ground. The voltage used should be twice the rated voltage of the apparatus plus 1,000. Also, it is sometimes necessary to apply high voltage to a grounded armature so as to locate the ground and patch it. The same tests are made on field coils, transformers, auto-starters, and in fact to almost all electrical apparatus that goes through the electrical repair shop of an industrial plant.

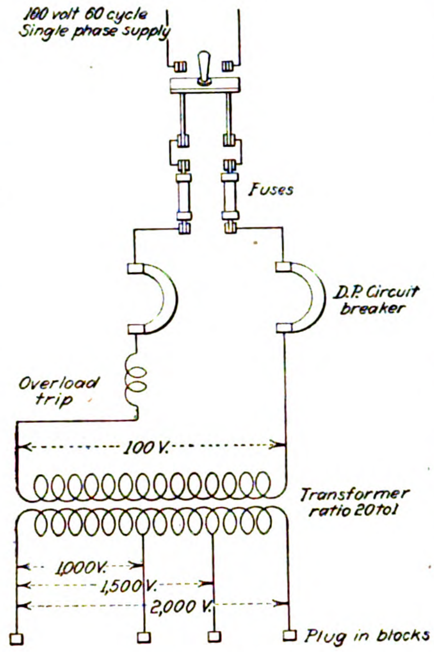
A test set that is capable of doing this work and has the advantage of being portable is shown in the accompanying illustration. This set can easily be made from materials that are at hand in most electrical repair shops. A cart for carrying the set was made by mounting wheels and a handle on a platform, as shown in the illustration. The transformer was placed on the platform and on the panel attached to the transformer were mounted a circuit

breaker, knife switch, fuses and a plug-in block for the high-tension leads.

The transformer is an ordinary 5-kva, distribution, pole-type transformer, rated at 2,200 volts on the high-tension side and 110 volts on the low-tension side. The transformer is laid on its side and bolted to the platform of the carriage. Since the transformer receives only intermittent service, it is unnecessary to use transformer oil in it. A wooden or asbestos-board panel is bolted to the top of the transformer and the circuit breaker, knife switches and fuses bolted thereon, as shown in the illustration.

The low-tension side of the transformer is connected, as shown in the diagram, through a double-pole circuit breaker, fuses and knife switches. It is connected to a 100-volt, single-phase, 60-cycle supply. A 110-volt, 60-cycle supply would do just as well, although the high-tension voltages would then be 550 volts, 1,100 volts, 1,650 volts and 2,200 volts. The circuit breaker should be set to trip at 20 amp. and 35-amp. fuses should be used.

Special taps have been made to the high-tension winding, as is shown in the diagram of connections. A tap is made in the middle of the high-tension winding and at three-quarters way through the winding so as to give approximately 1,000 volts and 1,500 volts respectively. These taps are brought to the plug-in block, shown in the illustration, mounted above the transformer. The high-tension leads can be plugged into this block to obtain 500 volts, 1,000 volts, 1,500 volts or 2,000 volts. Five hundred volts are obtained by plugging into the two middle receptacles. The remaining voltages are obtained by plugging as indicated in the accompanying diagram.

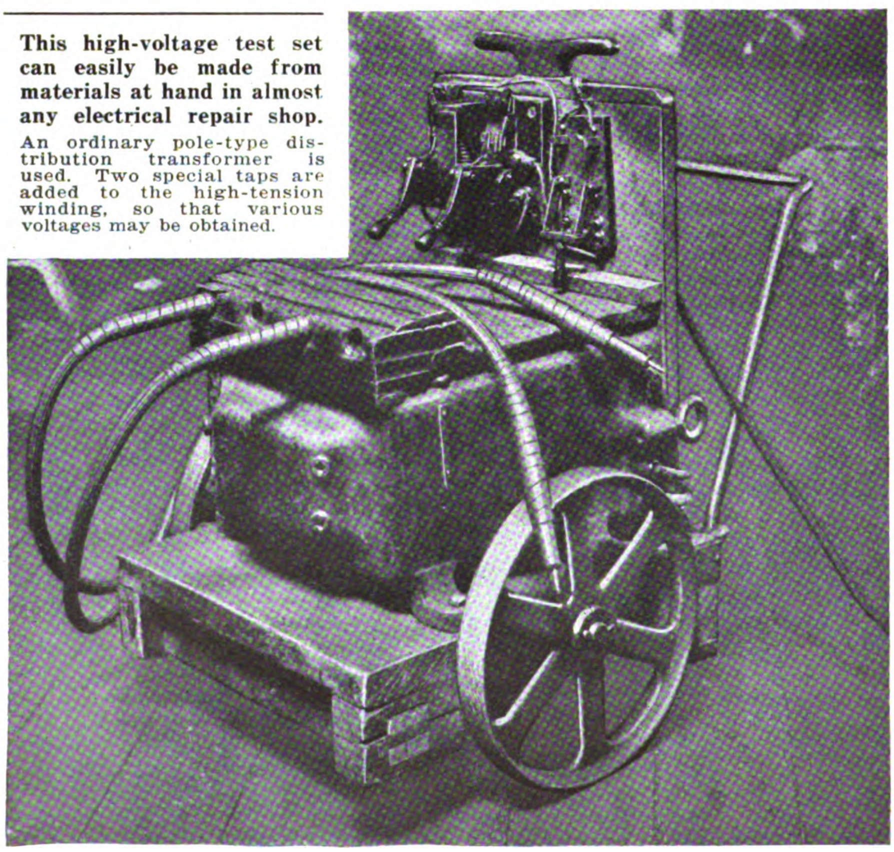


Four values of high voltage for testing can be obtained from this high-voltage set.

Five hundred volts are obtained from the two middle blocks. The other three voltages are indicated in the diagram.

The high-tension leads are made of No. 6 or No. 8 extra-flexible, rubber-covered wire. The leads should be about 10 ft. long and are placed in a good grade of rubber hose to protect the wire and to give the increased insulation required for the high voltage. The ends of the hose are taped so as to make a neat appearing job. A hook-shaped or spike terminal may be used on the testing end of the leads. The connection end should have a plug terminal to fit the receptacle in the plug-in block. E. M. FEHRLIN.

Diehl Manufacturing Company, Elizabeth, N. J.



This high-voltage test set can easily be made from materials at hand in almost any electrical repair shop.

An ordinary pole-type distribution transformer is used. Two special taps are added to the high-tension winding, so that various voltages may be obtained.

Broken-Down Insulation Cause of Trouble With Rotor

RECENTLY we found out what was the matter with a 15-hp., 440-volt, three-phase, fifty-cycle, squirrel-cage motor which drives a foundry sand mixer having a capacity of eight wheelbarrowfuls. This motor had been in operation about two years and had always given trouble. When the mixer was set up it was given a try-out at full load and as the sand was a trifle damp it was noticed that the motor hesitated about getting up to speed.

Later on, dry sand was used and the motor still slowed down perceptibly. In fact, when the sand was shot out of the chute on to the mixing blade the motor would almost stop. The trouble was slightly relieved by using less sand, but for many months this condition was tolerated without knowledge of the real cause; the wattmeter even failed to show any continued overload. During the past few weeks the motor slowed down more than ever. When the load came on it would practically stop for about five seconds and then slowly speed up to normal.

The mixer was looked over for tight bearings, the starter contact fingers were examined, the motor was thoroughly cleaned and its bearings tested, new oil was supplied, the winding tested for grounds, and the line examined for poor connections, but no cause for the trouble could be located.

The winding did not at any time heat up above normal and the only apparent trouble seemed to be that the horsepower was getting less and less, until the motor could carry little or no load at normal speed. The motor was finally taken apart, the winding examined for defects and tested for grounds, all the coils were closely scrutinized for short-circuits, poor insulation, loose connections, and so on, but no defect was found.

As this was not a wound rotor it did not seem to have any bearing on the problem, but after going over the other parts of the motor very carefully the rotor was rolled over and closely examined. It was then seen that about twelve slots showed slightly burned edges. The insulation covering these rotor bars was carefully picked away with a fine-pointed tool and many holes were found side by side in the twelve slots. The spots were not caused by the rotor striking the stator as the bearings were perfect. Also, as the motor was covered by a metal hood, it was not possible for a pebble or other small object to have got into it.

These defective slots were blamed for the slowing down of the rotor, and another motor was installed. The defective rotor was returned to the manufacturer and a new one procured; from that time on no trouble was ex-

perienced, the speed and power being satisfactory. Thus the whole trouble was caused by the broken-down insulation in twelve slots of the rotor.

New Britain, Conn. H. S. RICH.

Easy Method of Making a Handy Lead-Faced Hammer

THE article by G. A. Luers, describing a detachable brass head for a machinists' hammer, on page 207 of the April issue of INDUSTRIAL ENGINEER reminds me of a very handy hammer that I have in my set of tools. It is made from a tee pipe fitting and a piece of ½-in. pipe for a handle. The interior of the fitting is filled with lead and cast iron.

It is a very simple matter to make a mold for pouring the lead into the fitting so that the faces will project sufficiently far to prevent the cast iron from striking against the delicate part that is being struck.

To conserve lead I filled most of the space inside of the fitting with pieces of cast iron, the lead being poured around them.

A hammer of this kind is very useful for pounding delicate metal parts that would be battered by a steel, iron, or even a copper face.

As soon as the faces wear away simply throw the entire hammer into the melting pot, melt the lead out and repour.

Newark, N. J. N. G. NEAR.

Improper Soldering of Commutator Leads Causes Trouble

THOSE who rewind or repair armatures know that more trouble develops in the commutator than in the coils. Of the three troubles commonly found in armatures—grounded bars, bad mica and poor connections—I feel safe in saying that more damage is done by poor connections than by the other troubles. Many times the failure of the winder or repair man to take a little more time to do his work thoroughly when rewinding or repairing an armature, is the reason why it stays in service for only a short period of time, compared to what it would have done had he soldered the leads in the commutator more thoroughly.

It will often be noticed that there are several black bars on a commutator. In many cases, particularly where the machine is lightly loaded, this does not cause any trouble except possibly a slight sparking. Often, however, this condition gradually grows worse even if the commutator is turned down frequently, which should not be done as it does not remedy the trouble and causes a heavy loss of copper from the commutator.

When a motor or generator is running under a fairly heavy load it will not function properly unless there is good commutation. By "good commutation" I mean in this case, reversal of current with as little opposing resistance as possible. An improper connection, where the leads are soldered into the commutator bars, makes extra and unnecessary resistance. Current will not pass through a poor connection as well as it will through a solid one and when it is forced causes heating.

Armatures usually look as though the leads are perfectly soldered because there is solder on the front of the riser and an abundance on the top. Bear in mind that it is usually the bottom leads that are neglected. Therefore the good appearance of the top and front mean nothing. It is possible that there is only about 1/16 or ⅛ in. of solder back in the slots because the shoulder has been turned off smooth after soldering. When the bottom leads have not been sweated in trouble often arises because the copper tarnishes in the slot and offers a high resistance to the passage of current. With high resistance, heat is generated and many times a very hot commutator or an excessively warm armature may be caused by poor connections. It is only when the connections become very bad that serious trouble results. As a general rule, there will be a blackened bar or two where the trouble is and if it is not attended to when the commutator commences to spark badly, the solder may be melted out and a partial or perhaps a complete open circuit will result.

The black spots on the commutator will occur either on the third or on the half, or in just one place, depending on the way the armature is connected. On an armature of a bi-polar machine, there will likely be only one black spot as these armatures are connected 1 and 2. On a four-pole machine there will be two spots diametrically opposite, although there will be trouble at only one of them. On a six-pole machine there will be three spots on the third. This is in case there is only one bad connection showing up. When more than one is in evidence, the number of spots is increased in direct proportion to the number for one bad connection.

The reason that only one of each two or three black spots is the seat of the trouble is due to the fact that if the armature coils are connected for a four-pole machine the current must pass through two coils before returning to the bar next to the start. Therefore, there are two simultaneous reversals under opposite brushes causing two black spots; one where the trouble is and the other diametrically opposite to it. In the six-pole machine the coils are connected on the third and therefore the current passes through three coils before returning to the bar next to the start, causing three reversals simultaneously and also three black spots for each poor connection.

Recently I worked on a large generator that had twelve black spots on the commutator. As it was a six-pole machine, I picked out the four worst spots and lifted the leads. After cleaning and tinning the leads they were laid again and well soldered. This cleared the trouble.

Often the insulating varnish with which the armatures are impregnated after winding, will soak up in the back of the commutator and into the slots, if the leads are not soldered well. This is a very bad condition and soon develops trouble.

When clearing trouble due to poor commutator connections, do not just solder over the leads. Take them out of the bar and clean them well, also cleaning the slot in the bar with a hacksaw blade. Tin the leads before relaying them. This insures that the solder will flow to the bottom of the slot. If the commutator is very rough the best policy is to turn it off, although in many instances a sandstone or piece of emery stone will grind it smooth. It will be noticed that the mica between the blackened bars is a little higher than the copper. This leads many repairmen to believe that these particular mica sections are harder than the rest. They advise under cutting the mica. It must be said that this will relieve the sparking temporarily or at least lessen it, but the real trouble still remains. Where the commutator is blackened all around it shows that the brushes are not in the neutral plane, the machine is overloaded or the mica is too hard to wear down with the copper. In the case of hard mica, the only way to relieve sparking is to undercut the mica or else continually grind it smooth with a sandstone. Harder carbon brushes might also help, but undercutting the mica will often be very beneficial.

When a machine is overloaded, it is to be expected that some trouble will develop at times. An armature is more likely to develop trouble from poor connections when it is overloaded or loaded to capacity. Good soldering means satisfactory service and inasmuch as an armature winder usually does not know under what conditions the armature he is winding will work, he should make sure that he does a 100 per cent job of soldering.

Darby, Pa. GEORGE WM. HANLON.

Two Quick Methods of Stripping Closed Slot Armatures

THE question sometimes arises as to the best and quickest method of stripping a closed-slot armature. I have found that the best way of doing this is to burn off the old insulation in the slots and on the coil ends by applying a gasoline torch. If a torch is not available, wrap an old rag around the armature and saturate the rag and the winding with kerosene. Then take the armature out to an open space in the yard and set fire to it. Keep the flames away from the commutator as much as possible and strip the armature while it is still warm. The fire will not harm the laminations.

Another method which gives good results is to soak the winding in a hot solution of lye or Oakite. For this purpose, put a lathe dog on the commutator end of the shaft and either dip the armature until the winding is submerged, or hang the armature over the tank and pour the solution over the winding. Keep the commutator clear of the solution except where it is necessary to remica the commutator, in which case the whole armature can be submerged. After stripping bake the armature to drive out all moisture between the laminations, before rewinding.

Detroit, Mich. A. C. ROE.

Budgeting Maintenance Expenses

(Continued from page 316)

any over-runs must be justified by an explanation. The reasons for weaknesses and leaks are thus pointed out and rectified.

Sometimes it is found necessary to change the budget and to take care of this we have in use a form known as a "Request for Budget Change" (Fig. 3) which calls for an explanation as to why a change is necessary and has to have the approval of the general manager before it is taken into the records.

Of course, if there is a radical change in the sales or orders received as compared with our estimates an entire budget revision is necessary; in fact the budgets are gone over monthly with such revisions in view if necessary.

As an additional curb on the maintenance expenses, and so that we will have a complete accounting record of such work accomplished and the means for a correct allocation of charges, it is necessary for the foreman of any department to secure a Work Order, shown in Fig. 7 before any work is undertaken by the maintenance engineer. Full explanation of what is wanted and the reason why the work is required has to be detailed on this order and the approval of the superintendent or factory manager secured before the work is started except, of course, in the case of a breakdown job when, naturally, the work is at least started without waiting for the paper work to be completed.

On the reverse side of the accounting department copy of the Work Order are posted the details of the materials used, taken from the stores requisitions covering the withdrawal of the items from stores and the labor charged to the work, posted from the maintenance employees' time tickets.

These work orders cover both maintenance and plant additions; a monthly closing is made of any of the latter which are completed and the totals transferred from Uncompleted Plant Account to Completed Plant Account and allocated to the department involved. In the case of the maintenance orders the charges to all of these are closed out monthly and chargd to the particular maintenance expense account of the department for which the work has been done.

As the result of two years' experience with a budget system for maintenance and repair work, as we handle it, the following advantages are apparent: (1) Maintenance and repair costs can be closely estimated and controlled. (2) An accurate record is provided of the quantity and quality of the work of the maintenance department. (3) The foremen of the various departments have been led, by their desire to make a good showing in their department, to take a deep interest in maintenance work and thus assist the maintenance department in many ways. An incidental result has been the cutting down of power, heat, light and other like expenses through prevention of waste. (4) Performance of unnecessary maintenance or repair work is avoided. (5) A definite relation is maintained between production and maintenance expense. (6) Although the budgets are made up a year in advance, provision is made for increasing or reducing the estimated figures as conditions indicate.

Coil Insulation Troubles

(Continued from page 337)

The disadvantage is that when applied to coils operating on higher voltages where heat is developed in service the partial vacuum inside the windings prevents the transfer of this heat to the outer surface of the coils.

Treatment of Cotton-Covered Enameled Wire.—In this relation it must be remembered that we are dealing only with plain enameled wire coils. While the same practice is entirely suited to the treatment of cotton-covered enameled wire the precautions need not be so carefully followed out. The cotton serves as a space factor and prevents the conductors from actually coming in contact and short circuiting. The only danger is that the cotton may be pushed to one side, thus leaving the enamel on adjacent turns exposed to the action of the varnish solvent. Again, the fibrous insulation provides a greater surface for the entrance of heat and air, thus giving a chance for thorough and rapid drying of the varnish. Even those varnishes which are not advised for enameled wire work have been found to be quite successful for this kind of application because their solvents, although slower drying and having higher solvent powers, will remain in contact with the wire for an even shorter period than would be experienced in the case of the closely wound coils in which the plain, uncovered enameled wire is used.

You will observe that throughout this article the writer has emphasized the methods of treatment and the process of baking as the cure for all difficulties that may occur when there is no doubt that the proper type of insulation has been used.

Don't jump at conclusions. When trouble arises in connection with the insulation of a coil do not blame the wire, the tape, or the varnish employed in its construction. Follow the practice of a good cook. When a cake is spoiled she does not lay the blame on the brand of flour, eggs, baking powder, or other ingredients. She is not necessarily a brilliant person, but common sense has directed her to use only those products which she knows are right because they have been tested by time and experience. Hence, she examines first her methods of combining the various ingredients and observes wherein she has departed from that practice which previous knowledge tells her will always produce good results. If her methods are right, the oven next comes under her observation and she checks up on the temperature to make sure that the baking was carried out under proper conditions. Only as the last resort, when continued trouble under ideal circumstances is experienced, does she change the source of raw materials supply.

Just so with insulating varnishes. Select those materials which have stood the test of time and service. Keep a careful record of the oven conditions and your method of application. Then, should trouble occur, check up on all these details and observe the departures that have been made from those methods which previous good results show you are the correct ones to use.

If in spite of all precautions trouble still continues, consult your source of varnish supply. Having specialized in the problems of electrical insulation he should be in a position to render valuable aid.

The next, and final, article of this series will appear in an early issue of INDUSTRIAL ENGINEER. It will take up in detail the points to be considered in the selection of the proper insulating varnish for use, in view of the conditions under which the machine is to be operated.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Lewis-Shepard Company, 588 East First Street, Boston 27, Mass.—A booklet entitled, "These Twenty-four Business Concerns Increased Profits $59,565.88 Yearly," gives a list of concerns which have made savings by the use of Lewis-Shepard industrial lift trucks. For each concern the tabulation gives the cost of the equipment and the saving which is made during a year.

Electrical Machinery Manufacturing Company, Minneapolis, Minn.—Bulletin 833 shows the construction of the E-M Junior synchronous motors from 20 to 100 hp. for direct connection to small compressors. This bulletin also shows the advantages of the synchronous motor and in addition gives several pages of discussion to its operation. Bulletin 785 is entitled "Some Users of E-M Synchronous Motors and Vertical Alternators." A special chart indicates some of the possibilities of applying synchronous motors to equipment in different industries.

Acme Electric Heating Company, Department I, 1217 Washington Street, Boston, Mass.—A 32-page loose-leaf catalog illustrates and describes the various types of Acme electric heating devices for domestic and industrial use. These include disc and plate heaters, immersion and circulation liquid heaters (about sixty forms of immersion coils are illustrated by sketches), tube immersion heaters, electric steam boilers, various kinds of electric pots and ladles for melting sealing wax, metal, glue, pitch and other substances, embossing press heaters, tool heaters, as well as laboratory, laundry and kitchen electric heating equipment. Several pages are also devoted to electric radiators, foot warmers and to space and cartridge heaters.

Howell Electric Motor Company, Howell, Mich.—A new 16-page booklet entitled, "Give Red Bands Your Hard Jobs," describes and illustrates the construction of the various types of Red Band induction motors. Some of the topics discussed are: Frame construction, windings and stator insulation, the indestructible rotor, shafts, bearings, endplates, slide rails, starting equipment, starting torque and anti-friction bearings. Considerable space is given to a description of the method of winding the coils in slots so as to give heavy and durable slot insulation. This is also accompanied by a report of the Electrical Testing Laboratories which shows the high puncture rating of the double-cotton enameled wire used in this winding compared with other types of wires. Slip-ring motors, vertical motors and other special types of motors are also illustrated and described.

Stop Wall Plugs Company, 53 Park Place. New York, N. Y.—A folder describes the "Stop Plug" which is a hollow tube of stiffened fibre used for holding screws and hooks securely to any wall. A hole is first drilled into the wall which may be of stone, cement, tile or other material, the stop plug is inserted and as the screw is inserted into the hollow stop plug it expands the fibre to a tight fit in the opening. Screws may be removed and reinserted.

Federal Steel Products Company, Inc., 2-14 Avenue L, Newark, N. J.—Catalog 2 covers the various sizes and prices of Federal safety switches and enclosing steel cabinets for electrical devices.

Structural Slate Company, Pen Argyl, Pa.—A 90-page book entitled: "Slate for Electrical Uses," revised edition, contains the researches concerning natural slate made by it and also tests performed under the direction of the Structural Service Bureau of Philadelphia, Pa. Among the subjects discussed are: The development of electrical slate, uses, testing for electrical uses, specifications (electrical and physical), recommended mounting practice (with sketches), applications (illustrated), and several pages of information and engineering data.

Roller-Smith Company, 233 Broadway, New York, N. Y.—Bulletin 160 covers the Type GSA alternating-current, portable ammeters, voltmeters, volt-ammeters, single and polyphase wattmeters, frequency meters, power factor meters, transformers, multipliers, Y boxes and other instruments.

American Fixture Company, 230-232 West Water Street, Milwaukee, Wis. —Supplement catalog 4, shows the condulet adjustable electric light fixtures by which adjustable arms are fastened to ½-in. or ¾-in. condulet and so do away with exposed wires.

Union Electric Manufacturing Company, Milwaukee, Wis.—Publication 500 gives the "General Specifications of Design" on general purpose, drum-type starters and speed regulators, reversing and non-reversing, with accessories for alternating-current motors of wound-rotor or slip-ring types. Publication 500-A gives the list prices.

James G. Biddle, 1211-13 Arch Street, Philadelphia, Pa.—Pocket Manual 1060, "Concerning Insulation Testing with Special Reference to the Meg" is a 48-page book containing up-to-date data on the insulation of electrical apparatus, causes of breakdown, effects of moisture, surface leaks, temperature, etc. It describes the "Meg" and "Super-Meg" insulation testers (new instruments similar to "Megger" testing sets) and gives full directions for making "Meg" tests on practically all types of electrical apparatus. The manual is illustrated with charts and photographs.

Becker Brothers, Inc., 23 North Jefferson Street, Chicago, Ill.—A chart about 18 in. by 22 in., suitable for attaching to the wall for easy reference, is entitled "Physical Characteristics and Standard Qualities of Carbon, Graphite and Metal Brushes." The chart gives for each of the six groups of brushes, the general properties of that group and the following information on each grade: Mark, specific resistance, current density, co-efficient of friction, contact drop, hardness, breaking strength, peripheral speed, pressure recommended and a short recommendation for its use.

The Leather Belting Exchange, 119 South Fourth Street, Philadelphia, Pa.—This organization of belt manufacturers has had reprints made for distribution of the three articles by Robert W. Drake, Electrical Engineer, McCormick Works, International Harvester Company, on "When to Use Group and Individual Drives," which appeared in the Feb., Mar. and Apr. issues of INDUSTRIAL ENGINEER.

Grant Gear Works, 151 Pearl Street, Boston, Mass.—The new catalog and price list contains an unusually large amount of practical information on gears and gearings, such as: Drawing the standard involute tooth, drawing the spur gear wheel, drawing the bevel gear and bevel-gear tooth and a special bevel-gear chart as well as other necessary information for those interested in gearing.

Allen-Bradley Company, 491 Clinton Street, Milwaukee, Wis.—Bulletin 640 describes the Allen-Bradley Type H-1852, semi-automatic hand-operated, resistance starter. Simplicity of construction with every part readily accessible are some of the features claimed for it. Another feature claimed is that unless the operator starts the motor correctly, the contactor switch drops out and so protects the motor.

The Fuerst-Friedman Company, 1251-57 West Third Street, Cleveland, Ohio—Bulletin 27 lists in 40 pages the stock of the Fuerst-Friedman rebuilt, guaranteed motors and other electrical equipment, such as generators, motor-generator sets, plating generators, pulleys, rotary converters, speed regulators, switches and transformers, as well as blowers and fans.

The Cincinnati Specialty Manufacturing Company, Inc., 1907-17 Powers Street, Cincinnati, Ohio—A folder describes the Autex automatic extension reel which has a swivel-joint feature permitting the lamp, drill or other equipment to be carried in any direction and an automatic lock permitting it to stop at any desired point. The insulation and connections have been given a test of 1,250 volts, although only 250 volts are required on lighting circuits by the Underwriters Laboratory, Chicago. This reel is made in two types provided with 25 or 50 ft. of extension cord.

B. A. Wesche Electric Company, Cincinnati, Ohio—A folder describes the Wesche Uniframe motors which are made in Type H, steel frame, direct-current motor and the Type N, squirrel-cage, alternating current motor in ratings from ¼ to 50 h.p. These motors have the same dimensions as to size of base, height from base to

center of shaft and top of frame, and other overall dimensions for the same horsepower and speed rating, which facilitates interchangeability of direct- or alternating-current motors in the assembly and connection to motor-driven apparatus.

William Ganschow Company, 1001 West Washington Boulevard, Chicago, Ill. —General Catalog 100, entitled "Handbook on Gears and Speed Transformers" contains over 300 pages divided into eight sections as follows: (1) Speed transformers, compound and worm gear speed reducers; (2) Cut spur gears and pinions, machine-finished racks; (3) Bevel, mitre and internal gears; (4) Worm gears and worms, worm hobs; (5) Spiral, spiral bevel, automotive, helical and double-helical gears, and miscellaneous machine products; (6) Bakelite Micarta pinions; (7) Rawhide gears and pinions; (8) Miscellaneous engineering data. Many tables, charts and other instructive material are included.

Cleveland Crane and Engineering Company, Wickliffe, Ohio—Catalog 3 offers a complete line of Cleveland electric tramrails and shows by illustrations a large number of applications of hoists and tramrails in practically all kinds of industries. Each illustration is accompanied by a short description of the application. A number of sketches are given showing methods of laying out switches and track and also devices for erecting tramrails.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—Literature describes a new line of malleable iron, clamp structural pipe fittings designed for use with common wrought iron or steel pipe in the erection of outdoor or indoor electrical switching equipment. These malleable iron fittings can also be used for the construction of a variety of other work, such as racks, railings, benches or table frames, and with less difficulty than is encountered when ordinary pipe fittings are used.

Joslyn Manufacturing and Supply Company, 133 West Washington Street, Chicago, Ill.—Literature describes the McCollum electric hoists which are made in various sizes up to 5-ton capacity. These differ from the ordinary hoist construction in that there are no holding or lowering brakes employed. This is accomplished by means of an arrangement of speed reducing gears so mounted that they can be rotated only from the motor end and the load cannot cause the gears to rotate.

Western Electric Company, Inc., 100 East Forty-Second Street, New York, N. Y.—The Western Electric "Lighting Manual" discusses in simple terms the fundamentals of electric lighting and in addition describes representative systems of lighting available as well as offering suggestions to assist in selecting and applying those most appropriate and useful to commercial and industrial lighting systems.

Earl G. Trent, 1524 Chestnut Street, Philadelphia, Pa.—Leaflet T-A 2 describes and prices the Trent automatic control system for continuous service which not only indicates the temperature on a dial but controls the temperature by setting a lever to scale. Type 800 and 801 have a maximum range of 1,000 and 1,200 deg. F., respectively. Other types are made for a temperature from 100 up to 400 deg. This may be used for controlling electrically-heated devices, gas, steam, oil or air-heated appliances, for operating air or fuel valves independently or in conjunction, or for controlling the ratio of air and fuel valves and other uses.

Unit Costs of Lighting Systems

(Continued from page 332)

proper standpoint for him to think of lighting is in terms of his wage account, his payroll. It is not of any great consequence whether an installation costs $10,000 in a given space or $5,000, or $20,000. That is investment. The question is, what are the results he is going to get out of that investment by its use?

I have in mind one particular example where a lighting installation cost $6,000 in a portion of a building, and without any juggling of figures whatever it actually produced a 10 per cent saving in a $200,000 payroll, or $20,000 per year. I have no doubt that those of you who are also in the industrial field know of similar examples.

So I think that while we can cater to the prejudice of the man who must have his actual figures in dollars and cents, the thing we should do is to put the "soft pedal" on it just as far as we can, and present to him the lighting cost as a percentage of payroll. Of course, that will vary. For example, in the textile industry, in the weaving rooms where they use automatic looms, one operator may tend to twenty looms, and let the looms run for a half hour after the workmen are gone; the cost of light per operative is relatively high because every one of the twenty looms has to have exactly as good illumination as if attended by a single operator.

On the other hand, in many of the mechanical operations, as automatic screw machinery work in the automobile industry, where the operatives and machines are very close together, lighting is a very insignificant factor of the payroll.

But when all is said and done, lighting is an investment and its value is in labor and output and not in the cost of its operation.

James M. Ketch: From the strictly commercial standpoint, I believe that the lighting problem will be simplified if both those who buy and those who sell come to think of lighting in the terms of unit cost.

Those who sell lighting or design it, know that the first thing asked of them is the cost. The difficulty of getting quotations on wiring costs and on lamp and reflector costs, will be very much simplified by a complete and comprehensive table worked up on the basis of unit costs.

Charles Gallo: Some of us who are called upon at times to design lighting installations have to give some attention to what reflecting equipment we shall recommend, and Mr. Tuck is to be congratulated on having given us at least the beginning of a method of comparison which, when it is properly standardized, will be easy, plain and simple to use.

Inasmuch as "general illumination" and "localized general illumination" are terms which do not always have the same meaning but which when applied under different conditions may mean different things, it would be well to test these various luminaires under identical conditions of spacing and of mounting height with respect to the working plane.

Davis H. Tuck: With regard to what Mr. Elliott said, one of the advantages of this unit system is to get the man's mind off the reflector that he is going to buy and to bring his mind down to the working plane and get him to think about what he is going to receive. In using this unit cost we say nothing about the reflector equipment or how it is going to be installed, what spacings or the size of lamp, or anything of that sort. We tell him we are going to give him a certain number of foot-candles on his work, on his machine, where his man is working.

Mr. Gallo seems to think that this was a test between competitive reflector equipment. It was not a test at all. We went into plants that we could get into and got the actual installation figures. We had to go into plants where we had the co-operation of the electrical contractor who installed the equipment so that we could get the cost figures.

This paper is written with the idea of introducing the practicability of the term "unit cost" in lighting and is not meant to be a comparison between the relative merits of various reflector equipment. Of course it is possible to obtain definite results with a wide variety of equipment. Under such wide variety of types of equipment, however, the unit cost of installation and maintenance will also vary widely.

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Founded 1882 as the Electrical Review

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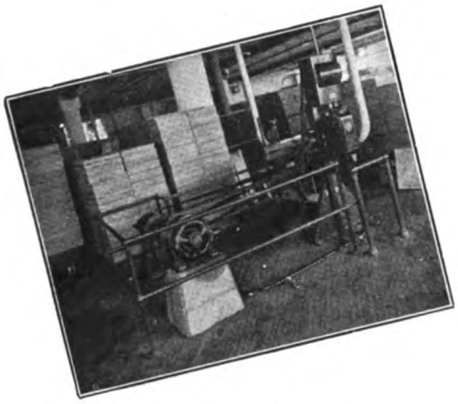
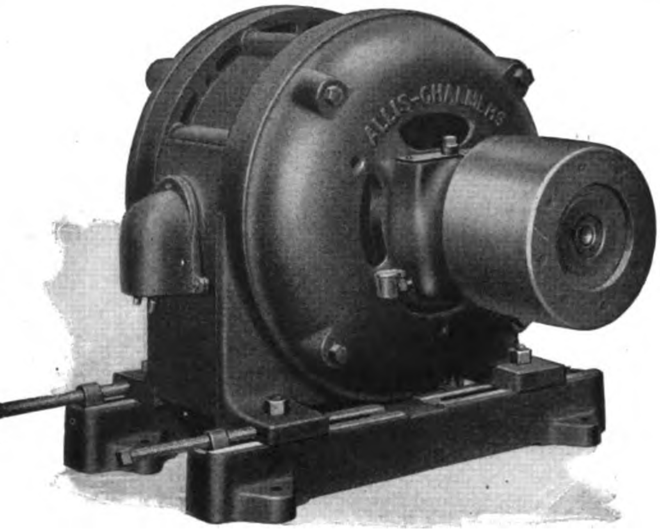
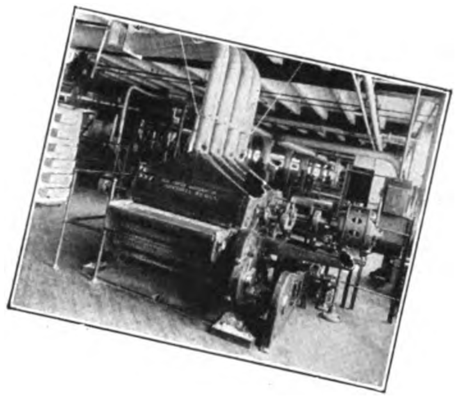


Polyphase



Induction

Type "AR" Squirrel Cage Motor



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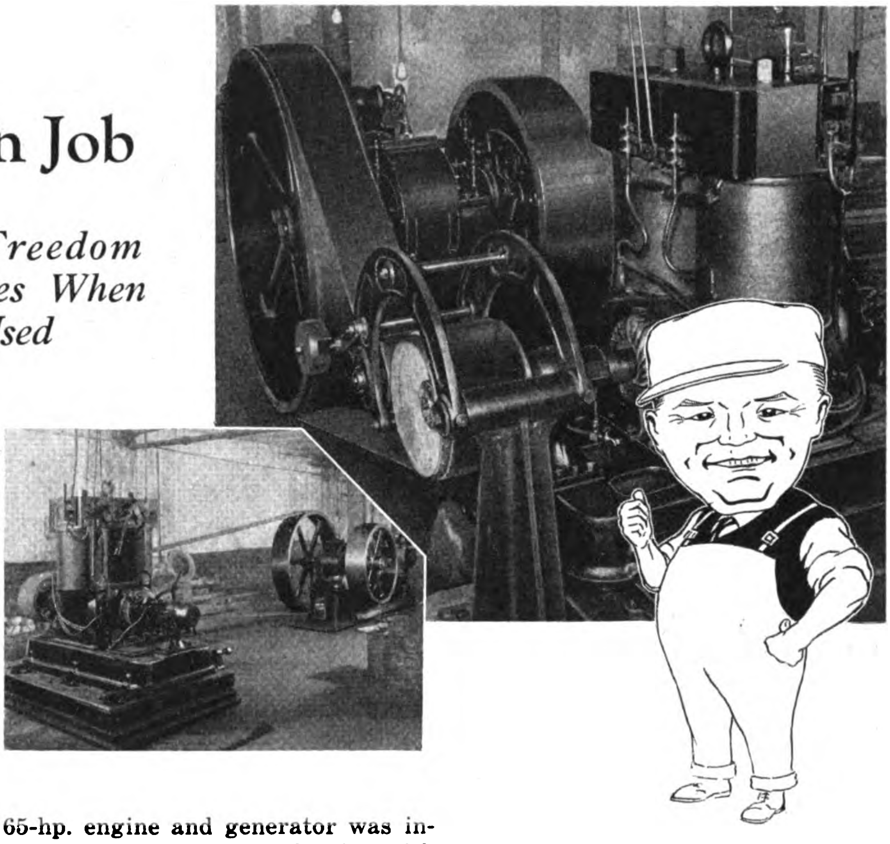
INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 82 Chicago, August, 1924 *Number 8*

The Proof of a Good Installation Job

Usually Shows Up in Freedom From Operating Troubles When Reliable Equipment Is Used



I WANT to take this opportunity of thanking those of our readers who have offered suggestions and contributed subjects for comment on this page. Practically every one is good and while there are not enough issues during the year to make use of all your suggestions, you have probably noticed that they have been developed into leading articles or shorter articles that have appeared in the practical departments following the two pages of editorials in the second half of the paper.

Mr. Martin A. Diller, of Intercourse, Pa., in the following comment touches on a subject that has brought out some interesting information from a number of readers: "Let's try and stimulate more pictures for *Practical Pete* on record installations showing long life or low maintenance of equipment, motors, etc." Here are two pictures from Mr. Benjamin F. Clark, an engineer associated with F. L. Smidth and Company, New York City, that show how troubles charged to an old belt drive were cured by inexpensive changes and the troubles traced to an inefficient installation of the belt rather than its use.

Until the pulley centers were shortened and the drive changed as shown in the large photograph, on June 14, 1908, this drive was cussed and discussed on frequent occasions. The original belt connection for this 65-hp. engine and generator was installed in the customary fashion with the distance between pulley centers 16 ft. according to the style of good belt drives then in vogue. The operator continually reported flickering of lights in spite of high belt tension and large amounts of belt dressing, with the pulley faces lagged with canvas to prevent belt slippage with wide variations in load.

Finally the generator was moved closer to the engine and a Lenix type of drive installed with pulley centers of 6 ft. 6 in. Mr. Clark states that since the change was made on June 14, 1908, the installation has been in daily operation and is still going. With the exception of one new belt, not one cent has been spent on this installation except for lubrication and no flickering of lights has been experienced.

This is another example of how good equipment gets a black eye through no fault of its own, but through indifferent attention to the conditions under which it is forced to operate. There are ways and ways of doing things, with some much better than others, but the proof of the best way is freedom from operating troubles.

You probably have in your plant some idea that you have worked out that proves this point. If so send me a photo of the installation and details of the operation and the rest I will take care of on this page.

Practical Pete

Achievements of Benjamin G. Lamme

Who Died at His Home in East Liberty, Penna., July 8, 1924

AMONG engineers the world around the name of B. G. Lamme is associated with developments in electrical engineering from their beginnings. He joined the engineering staff of the Westinghouse Electric & Manufacturing Company in 1889 and since 1903 held the position of chief engineer. Mr. Lamme in the early days devoted his attention particularly to the perfection of railway and industrial motors and synchronous converters. His first spectacular achievement was the designing of the generating equipment for the World's Fair in Chicago in 1892. Then came the 5,000-hp. generators for Niagara Falls, the largest built up to that time and the generating and motor equipment for the first large railway electrification project, installed by the New York, New Haven and Hartford Railroad. During the '90's he produced the Westinghouse Type C induction motor with squirrel-cage rotor and developed his advanced ideas on the design of synchronous converters, which furnished the battle ground of much discussion and established the background of practical fundamentals on which Mr. Lamme always based his development work and design theories.

Up to the time of his death he was always working on the perfection of existing or newly-developed equipment. His last large job was the design of the 62,500-kva. generator installed by the Brooklyn Edison Company last year. During the past thirty-five years more than 150 patents have been issued to him individually.

Mr. Lamme was well known for his ability to conceive the practical details of design from a mathematical study of the desired characteristics of a machine. At the very start of his career he showed a dislike for the cut-and-try methods of design then in vogue and began to develop methods for calculating designs on paper and building them from his conclusions. Scarcely six months after entering the employ of the Westinghouse Company, he calculated the electrical design of the double-reduction gear railway motor which was put on the market early in 1890. This was very similar in design to others that were in use at that time, so that this first piece of work showed little more than an ability to make the calculations of the magnetic circuit and determine the saturation curve.

In the summer of 1890, however, Mr. Lamme began work on the design of a street car motor with a single gear reduction. This was the forerunner of the celebrated Westinghouse No. 3 motor which set a standard for street car motors that still persists. It was radically different from anything that had appeared previously, with slotted armature, wound coils and a wave winding. Its success, when put out early in 1891, was instantaneous.

At this time, he was working on direct-current arc machines and alternating-current generators, making improvements in the latter which increased their output by 50 per cent. In 1892, he began work on the induction motor and produced the first successful, distributed-winding motor of this type. In 1892, Mr. Westinghouse took the contract for lighting the World's Fair. Great polyphase generators had to be designed for this purpose and Mr. Lamme did the work. He also designed the synchronous converter, large induction motor and other machines which were exhibited at the Fair. At this time he was designing railway generators whose performance was the boast of the Westinghouse Company.

Then came the Niagara Falls power development, for which Mr. Westinghouse took the contract for the electrical apparatus. The huge umbrella-type generators rated at 5,000 hp. each, were calculated to a nicety by Mr. Lamme, and the machines were a great success. About the year 1895, Mr. Lamme conceived the idea that led to the development of the type C, induction motor with squirrel-cage rotor.

However, he regarded his work on the synchronous converter as one of his greatest achievements. For years he fought, almost single-handed, the battle for the synchronous converter—and won out. This is now the accepted machinery for converting alternating into direct current.

Then came his conception of the single-phase, alternating-current railway system. After several attempts, Mr. Lamme succeeded in designing a series, commutator-type of motor with suitable characteristics, which he described along with the system of power distribution in his famous paper before the American Institute of Electrical Engineers.

The paper created a furore of excitement all over the world and soon every electrical manufacturer was working madly on the problems, and a dozen types of motors were on the market. Mr. Lamme never pinned his faith solely to the commutator-type motor, although that is the type that has been most used. He maintained that one of the great advantages of the system lay in the fact that several different types of equipment could be used, all running under the same trolley.

Mr. Lamme was not a prolific writer, but when he did write, the engineering world read with profound respect. He had the happy faculty of being able to put his thoughts on paper so that anyone with the rudiments of the subject could understand them. He seldom wrote mathematical papers, although not for lack of ability; he regarded mathematics as his tools that were to be put away when the work was done. Consequently, his papers are in great demand and are very widely read.

The American Institute of Electrical Engineers bestowed a high honor on Mr. Lamme by electing him one of the two members from that body on the Naval Consulting Board during the War. He was also chairman of the inventions committee on that Board. In 1919 he was also awarded the Edison Medal by the American Institute of Electrical Engineers for his engineering achievements. All of these were in consequence of his work and ability as an engineer. When the Board of Trustees of Ohio State University awarded him the Joseph Sullivant Medal. it was a recognition of the value of his engineering work to the world.

Mr. Lamme's greatness as an outstanding electrical engineer can best be judged by the eagerness with which engineers always sought his opinion and discussion.

B. G. Lamme was born on a farm near Springfield, Ohio, January 12, 1864. He entered Ohio State University in 1883 and was graduated in mechanical engineering in 1888.

The following is a list of 161 patents issued to B. G. Lamme, covering the patent number, subject and date filed. As far as the records show, this list is complete up to the present.

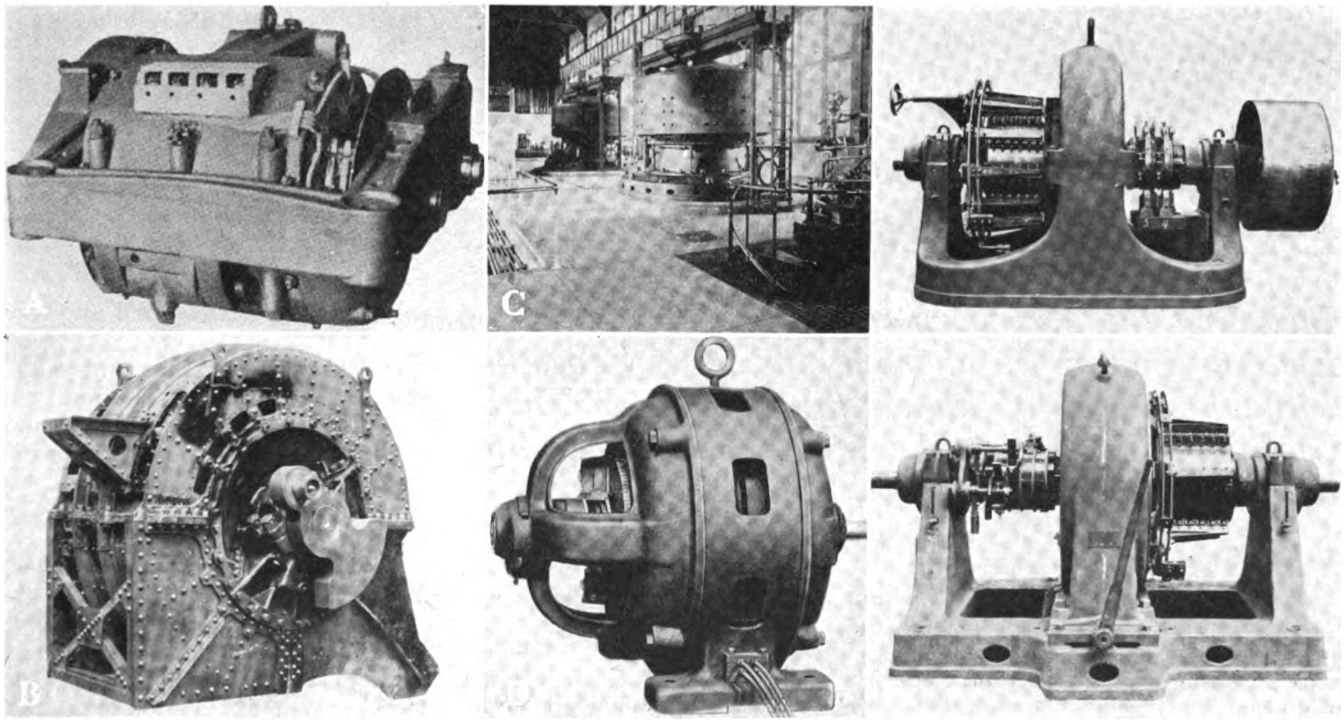
No. 488,016—Armature for electric machines. Feb. 8, 1892.
No. 513,401—Electric motor for street cars, March 27, 1893.
No. 518,693—Controlling switch for electric railways, Feb. 25, 1893.
No. 519,098—Self-exciting, constant-potential electric generator, Feb. 20, 1890.
No. 519,862—Method of, and means for, starting synchronous motors, April 5, 1893.
No. 520,965—System of electrical distribution, March 27, 1893.
No. 527,066—Device for protecting separately-excited generators, Feb. 28, 1894.
No. 550,354—Self-exciting, constant-current alternator, Aug. 24, 1891.
No. 556,891—Support for field-magnet coils, Sept. 4, 1895.
No. 559,721—System of electrical distribution, April 11, 1895.
No. 561,593—Dynamo-electric generator, Sept. 4, 1895.
No. 564,702—Alternating-current generator, April 30, 1894.
No. 564,703—Alternating-current generator, June 30, 1894.
No. 565,284—Compound-wound, polyphase generator, June 4, 1895.
No. 571,836—System of a.c. regulation and distribution, April 6, 1896.

Six well-known machines designed by Mr. Lamme.

A. Single-reduction, four-pole, wave-wound railway motor. *B.* Single-phase, 25-cycle, commutator-type motor for New York, New Haven and Hartford Railroad. *C.* Umbrella-type, 5,000-hp. generators installed at Niagara Falls nearly thirty years ago. *D.* Single-phase, 60-cycle induction motor developed in 1895. *E* and *F.* Two of Mr. Lamme's early designs of rotary converters.

No. 573,009—Direct-current, dynamo-electric generator, March 11, 1895.
No. 12,406—Direct-current, dynamo-electric generator. Original No. 573,009, dated Dec. 15, 1896. Application for reissue filed May 2, 1905.
No. 574,035—Method of, and means for, regulating a.c. generators, March 11, 1896.
No. 574,914—Means for adjusting compound-wound dynamos, Dec. 28, 1893.
No. 582,131—Alternating-current regulation and distribution, March 27, 1893.
No. 582,132—Alternating-current motor, Oct. 30, 1895.
No. 588,279—Direct-current generator, May 8, 1896.
No. 589,838—Coil for electric machines and method of making same, April 17, 1897.
No. 589,839—Armature for electrical generators and motors, July 2, 1897.
No. 599,940—Non-synchronous electric motor, April 30, 1894.
No. 599,941—Direct-current electrical machine. Original application filed May 8, 1896. Divided and this application filed July 8, 1897.
No. 599,942—Inductor dynamo, July 12, 1897.
No. 599,943—System of electrical distribution, Sept. 18, 1897.
No. 606,015—System of electrical distribution and regulation, Feb. 10, 1898.
No. 606,560—Regulation of rotary-transformer direct-current electromotive force, Feb. 10, 1898.
No. 606,589—System of electrical distribution, Jan. 28, 1897.
No. 607,621—System of electrical distribution. Original application filed Jan. 28, 1897. Divided and this application filed Dec. 16, 1897.
No. 609,990—Means for controlling non-synchronous a.c. motors, March 11, 1896.
No. 609,991—Method of, and means for, securing constant torque in polyphase motors, Feb. 10, 1898.
No. 610,067—Induction motor, July 22, 1897.
No. 620,333—Direct-current motor and method of operating same, Dec. 16, 1897.
No. 620,334—Direct-current system of electrical distribution, Aug. 4, 1898.
No. 620,335—Method of, and means for, varying speed of d.c. motors, Sept. 3, 1898.
No. 620,336—System of electrical distribution and regulation, Sept. 28, 1898.
No. 626,172—Rotary transformer or synchronous motor, July 24, 1897.
No. 633,855—System of electrical distribution, Jan. 30, 1899.

(*Continued on page 403*)



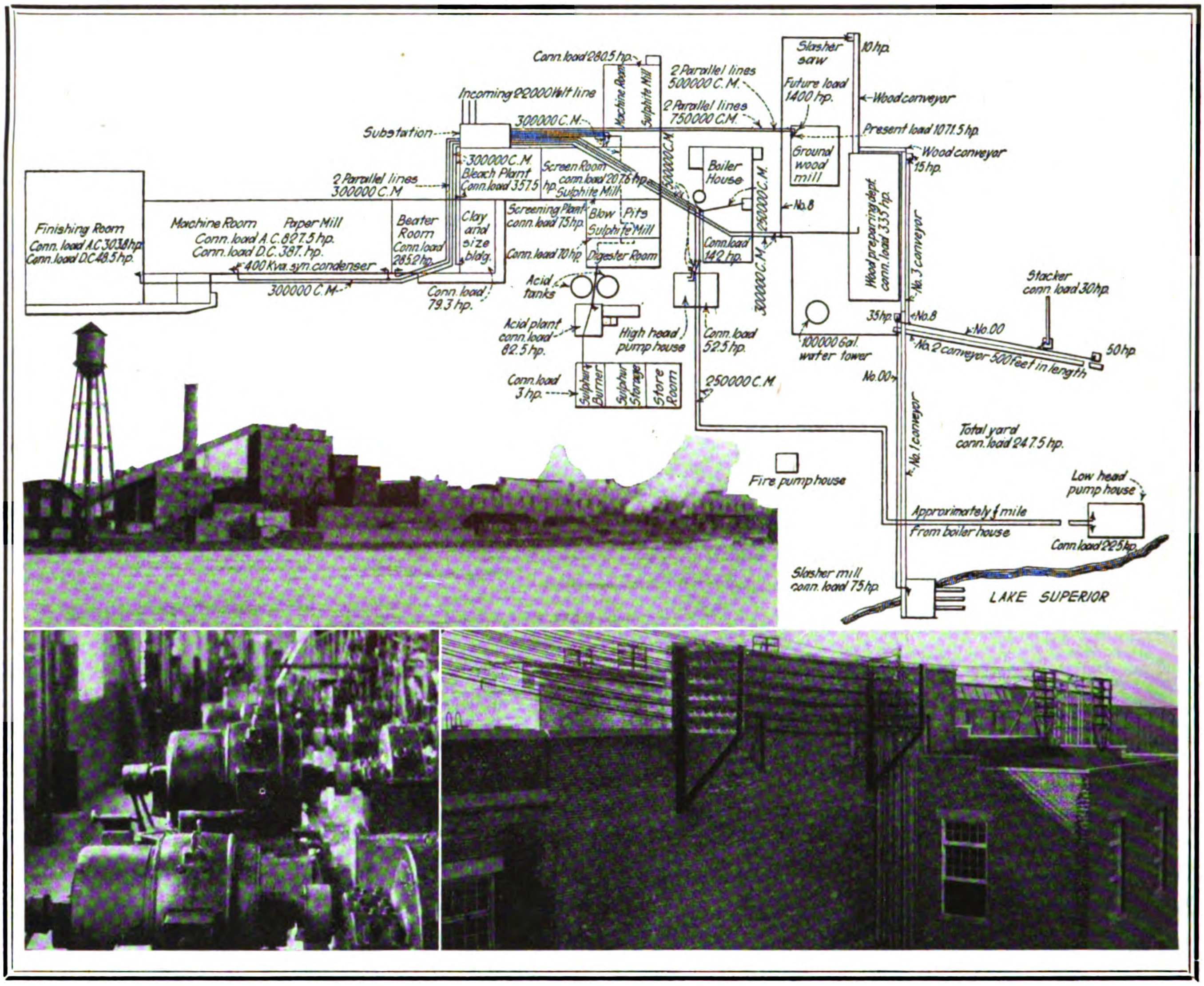


Fig. 1—Power distribution system of the Paper Mill shown in the center illustration.

Power is received at the substation shown at the top center of the drawing at 22,000 volts and is transformed to 575 volts and distributed to the various parts of the mill as is shown. The illustration at the lower right-hand corner shows the type of overhead distribution system used. This illustration shows the lines leaving the substation. The lower left-hand illustration shows part of the Harland drive in the *Book Mill.*

Factors That Determine the

Details of Paper-Mill Drives and Power Service

Including the Transformation and Distribution of Electric Power Throughout the Mill, Together with the Types of Motors and Kinds of Drive Used to Connect the Motors to Their Loads and the Characteristics of Paper-Mill Loads

By H. E. STAFFORD

Electrical Engineer, Provincial Paper Mills, Ltd., Port Arthur, Ontario

THE PLANT with which I am associated has a connected motor load of over 5,000 hp. It consists of a 50-ton sulphite-pulp mill, a 20-ton ground-wood mill and a 40-ton book mill. The sulphite-pulp mill employs a chemical process for converting wood into wood pulp for use in making paper. In the ground-wood mill, the wood is converted to wood pulp by actual grinding of the wood. In the book mill, the wood pulp is converted into book paper.

Outside of the steam plant, which supplies steam for cooking and bleaching the sulphite pulp and supplies steam to a turbo-generator which furnishes the power for the paper-machine drive, the mill is electrically operated throughout.

Power is purchased at 22,000 volts and stepped down to 575 volts at the company's sub-station. This is done by means of two banks of transformers, connected in parallel. One bank consists of three units of 1,250 kva. each, or a total of 3,750 kva. with 6 per cent reactance. This bank

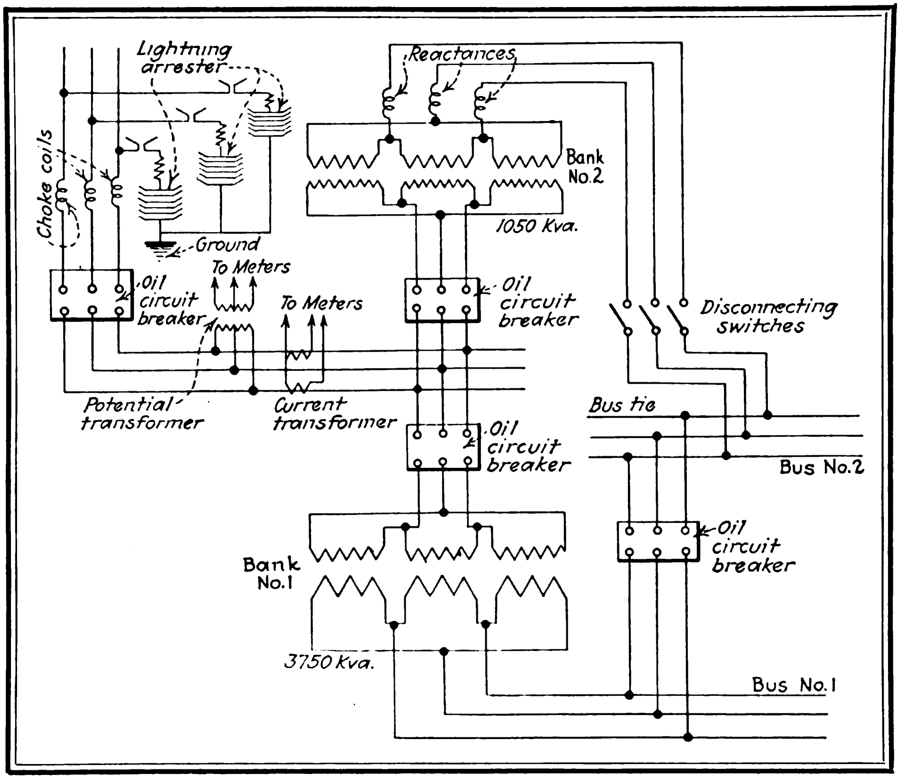
is shown in Fig. 5. The other bank consists of three units of 350 kva. each, or a total of 1,050 kva., having 2.5 per cent reactance. The additional reactance required for parallel operation is supplied by three reactances connected in the low voltage delta of the 1,050-kva. bank, as is shown in Fig. 2.

The scheme of connection is delta-delta and each bank is connected to a separate bus, with a bus-tie connection between them. There are two switchboards and the bus-tie is so arranged that either board can be fed from either bank. This is an additional precaution for securing continuous operation. Fig. 2 shows a diagram of the connections between the two banks.

The incoming 22,000-volt line passes through an oil circuit breaker, protected by three inverse-time-limit relays which are connected through three bushing-type current transformers, the trip being operated from a 12-volt, direct-current bus. Each bank of transformers is operated by an oil circuit breaker with a.c. trip. The incoming line is protected by aluminum-cell lightning arresters, as is shown in Fig. 2.

OF ALL the industries in the United States, the paper industry ranks sixth in horsepower of installed motors and in total consumption of electrical energy. With more than a million horsepower in motors, the paper industry is consuming more than 2½ billion kw-hr. per year. Where an industry uses such large amounts of power, the problems that must be considered are: The transformation and distribution of this power to the various motor drives, the types and sizes of motors to be used, and the manner in which the motors are to be connected to their loads. In this article Mr. Stafford considers each of these points in detail. He also gives some very interesting information as to the characteristics of paper-mill loads.

Fig. 2—This is the connection scheme of the transformers, switches and buses in the mill sub-station.
Note the external reactance connected in the low-tension side of the 1,050-kva. bank of transformers so that it can be operated in parallel with the other bank. By the arrangement of oil switches shown, No. 1 bank of transformers can feed either No. 1 or No. 2 bus. No. 2 bank of transformers is arranged to feed No. 2 bus only or to be operated in parallel with No. 1 bank to feed both buses. The feeders can be supplied from either bus.



The outgoing feeders from the sub-station were standardized by using 500,000-circ. mil, rubber-covered, stranded cable in 3-in. conduit, for all power runs. Where greater carrying capacity was necessary, two or more circuits of 500,000-circ. mil cable were paralleled. After leaving the substation the power cables were run on steel brackets, as shown in Fig. 4. All connections between rubber-covered and weatherproof cables were made with Dossert connectors. At the point of entrance to the various buildings, gutter boxes, equipped with bus supports, were installed and each motor was fed from a gutter box through an individual sealed service switch. Fig. 7 shows one of these layouts.

Table I shows the departments and subdivisions into which the mill is divided and also shows the connected load, average load and power factor of each subdivision. These data are charted in Fig. 3. Power is charged to each department on the basis of the average consumed.

Part of the wood for this paper mill comes by water and part by rail. Practically all the wood is in 8-ft. lengths, which have to be sawed into 4-ft. lengths for the sulphite mill, or into 2-ft. lengths for the ground-wood mill. The conveyors are arranged so that the wood coming by water may be either run directly to the mill or to the storage yard. The conveyor that takes the wood to the storage pile in the summer also brings it to the mill in the winter.

The handling of the wood is seasonal; that is, part of the equipment is idle in the winter and part of it is idle in the summer. For instance, the slasher mill, No. 1 conveyor, stacker and stacker conveyor are idle from November 1st to May 1st, while the slasher saw and at least one of the portable conveyors are idle during the summer.

The average summer load of this department is 110 hp. while the average winter load is 42 hp. The average power factor is 50 per cent lagging. Table II contains a list of the motors in this department.

Motors and Drives Used in a Sulphite-Pulp Mill

The sulphite process consists of wood preparation, acid making, cooking, washing and screening the pulp, turning out the excess pulp in laps for shipment to other mills, and reclaiming the waste screenings into laps for building and wrapping paper. For convenience, this process is split into four departments: wood preparation, acid making, sulphite process and screenings plant.

In the wood preparation department, the wood is barked in huge drums and made into chips of a uniform size for cooking. The chips are

screened to eliminate the sawdust and conveyed to a chip bin over the digesters. The average power used in this department is 164 hp., with a power factor of 68 per cent lagging. Table III shows the motor list.

In the acid making department, raw sulphur is burned and the gas thus formed is combined with other elements to form H_2SO_3, or sulphurous acid. This acid is afterward pumped to large storage tanks to be used in cooking the pulp. The average load of this department equals 50 hp. at 85 per cent lagging power factor. Table IV gives the motor list.

The sulphite-pulp process department includes the cooking, washing, screening and manufacture of pulp laps. There are two digesters, in which the cooking is done, each with a capacity of 16 tons of chips. The average load on the motors is 460 hp. with an average power factor of 85 per cent lagging. Table V shows the list of motors.

In the screenings plant, the screenings, slivers, knots and other refuse taken from the cellulose are refined by means of pebbles revolving within a drum, and the product thus formed is made into laps for shipment to mills making wrapping and building papers. The average load of this department is 65 hp. at 85 per cent lagging power factor. The motor list is shown in table VI.

Drive Applications Used in a Ground-Wood Mill

The ground-wood or mechanical-pulp mill may be divided into two departments: namely, wood preparation and ground-wood pulp process. The motors required for the preparation of the wood are given in Table VII, while Table VIII gives those for the pulp process.

Table I—Summary of Load in a Paper Mill

Department	Connected Load Hp.	Average Load Hp.	Power Factor Per-cent Lag	Table in Which Motors are Listed
I. Wood Handling	247.5	71	50	II
II. Sulphite Mill				
A. Wood Preparation	335.0	164	68	III
B. Acid Making	85.5	50	85	IV
C. Sulphite Process	684.4	460	85	V
D. Screenings Plant	75.0	65	85	VI
III. Ground-Wood Mill				
A. Wood Preparation	85.0	....	..	VII
B. Ground-wood Process	986.5	1290	98	VIII
IV. Bleach Plant	357.5	195	80	IX
V. Book Mill				
A. Clay and Size	79.3	30	50	X
B. Beater Room	285.2	275	85	XI
C. Machine Room				
1. A. C. Motors	827.5	660	100	XII
2. Harland Drive	359.0	....	D. C.	XIII
3. Dry End	28.0	....	D. C.	XIV
4. Finishing End				
a. A. C.	303.8	175	77	XV
b. D. C.	48.5	....	D. C.	XVI
VI. Steam Plant	142.0	75	65	XVII
VII. Water Supply	750.0	415	65	XVIII
VIII. Miscellaneous	90.0	70	100	XIX

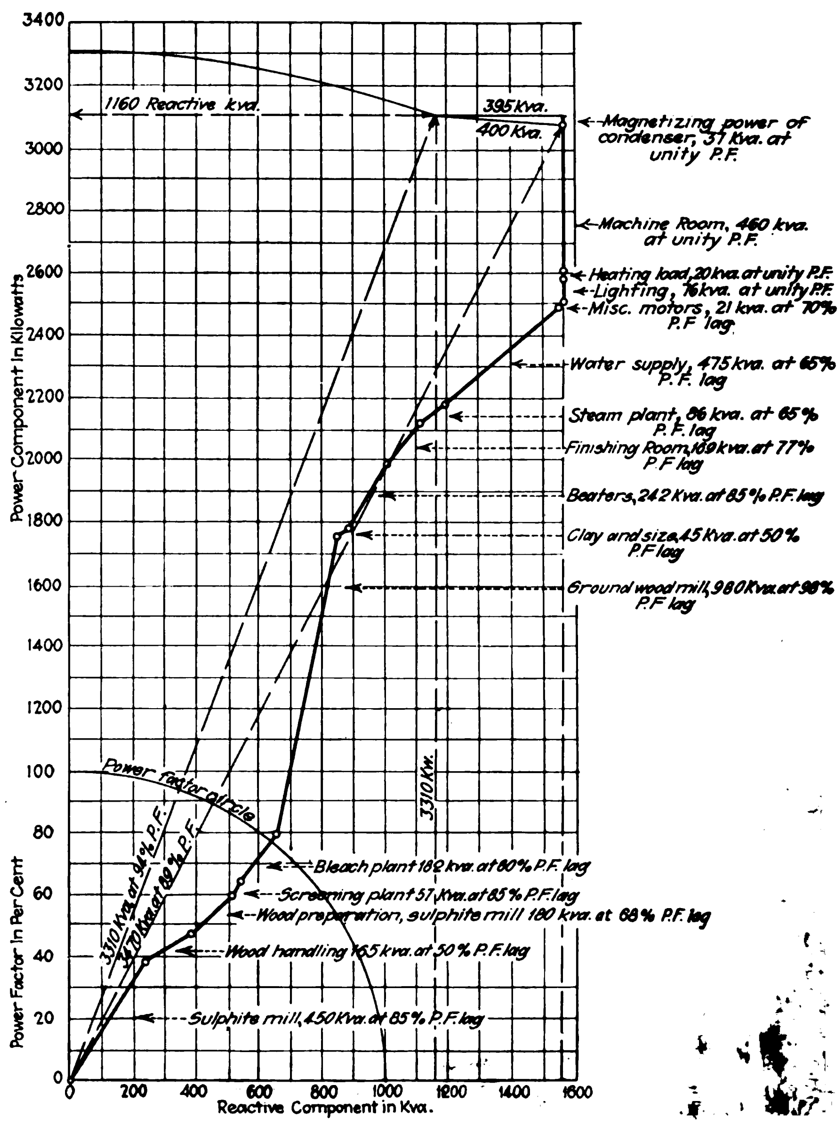


Fig. 3—Characteristics of the power load in a paper mill.

In this chart the loads on the different feeders running to the various departments of the plant are plotted against reactive and power components. The following characteristics will also be of interest:
Average annual connected load = 4,479 horsepower.
Average annual demand = 4,041 hp.
Average annual load = 2,658 hp.
Annual power consumption = 17,415,712 kw.-hr.
Cost per hp. of average connected load = $15.95.
Cost per hp. of average demand = $17.70.
Cost per hp. of average power = $26.82.
Cost per kw.-hr. = $0.0049 or practically ½ cent.
Annual load factor = 66 per cent.
Annual demand factor = 90 per cent.
Highest peak occurs in July = 5,228 hp.
Highest load factor occurs in Nov. = 78.5 per cent.
Lowest load factor occurs in Mar. = 42 per cent.
Highest demand factor occurs in July =100 per cent.

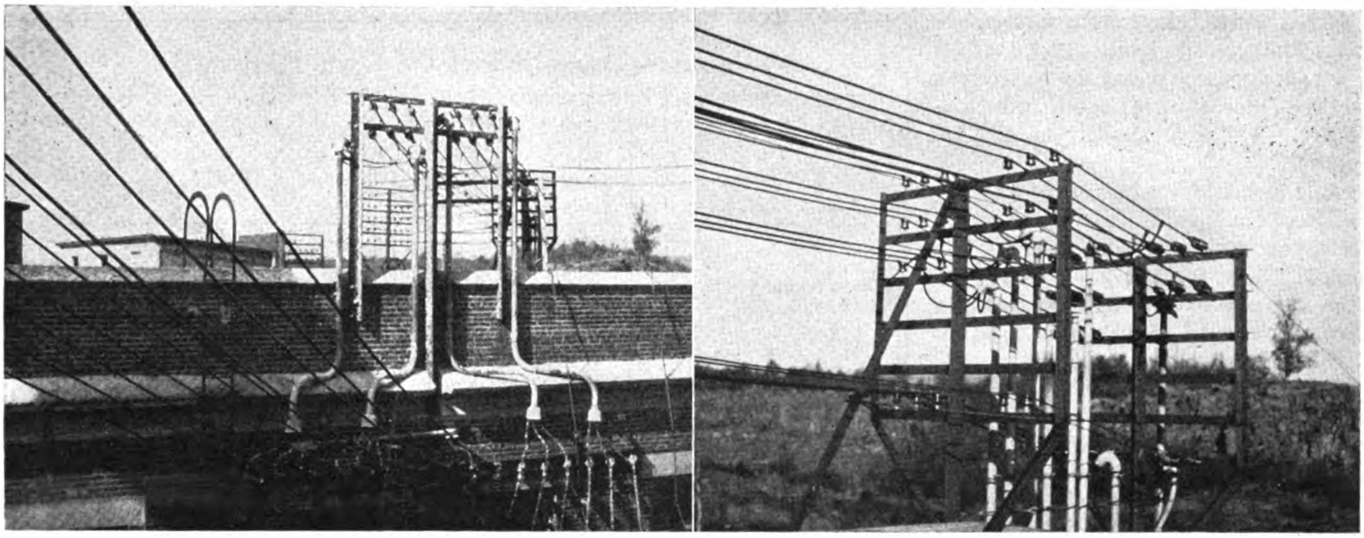


Fig. 4—The feeders to the various departments are carried overhead. The insulators are mounted on steel brackets which are supported on the roofs and walls of the buildings in the manner illustrated in the two pictures. In the illustration at the right is shown how the cables are dead-ended.

The average load of the entire ground-wood mill is 1,290 hp. at 98 per cent lagging power factor. The high power factor is due to the synchronous grinder motor operating at an overload and at high excitation. This motor is direct connected to two 3-pocket grinders and while of ample capacity for a water pressure of 50 lbs. per sq. in., is incapable of carrying the six pockets at the pressure needed to turn out the grade of pulp required. The six pockets are utilized, however, as two are charged with wood while the other four are grinding. The motor driving the grinder is shown in Fig. 8.

In the bleach plant, the sulphite and ground-wood pulp are further treated to make the pulp lighter in color. The bleach for the sulphite-pulp is chlorine gas, lime and other chemicals. That for the ground-wood pulp is sulphurous acid. Due to the action of these acids and gases this department is exceptionally severe on motors. The average load is 195 hp. at 80 per cent lagging power factor. Table IX shows the motor list.

Motor Sizes and Type of Drive Used in Book Mill

The present paper mill consists of one book machine with a capacity of 40 tons per 24 hours. This mill is divided into the following departments: clay and size, beater room, machine room and finishing room.

In the clay and size department, all the ingredients that go into a sheet of paper, with the exception of the pulp itself, are mixed. These in-

Table II—Drive Data of the Wood-Handling Department

Duty	No. of Motors	Type	Hp. Rating	R. P. M.	Drive
No. 1 Log conveyor....	1	S. C.	35	860	Belt
No. 2 Log conveyor....	1	S. C.	50	1,150	Belt
No. 3 Log conveyor....	1	S. C.	15	860	Belt
Portable conveyor......	1	S. C.	10	600	Belt
Portable conveyor......	1	S. C.	10	1,200	Belt
Slasher mill........	1	S. C.	75	860	Belt
Stacker...............	1	S. C.	20	580	Belt
Stacker conveyor.......	1	S. C.	10	600	Belt
Slasher saw...........	1	S. C.	10	600	Chain
Refuse saw...........	1	S. C.	5	1,800	Belt
Splitter...............	1	S. C.	7.5	720	Belt
Total.................	11	.....	247.5	...	....

All of these motors are three-phase, 550-volt, squirrel-cage (S. C.) induction motors.

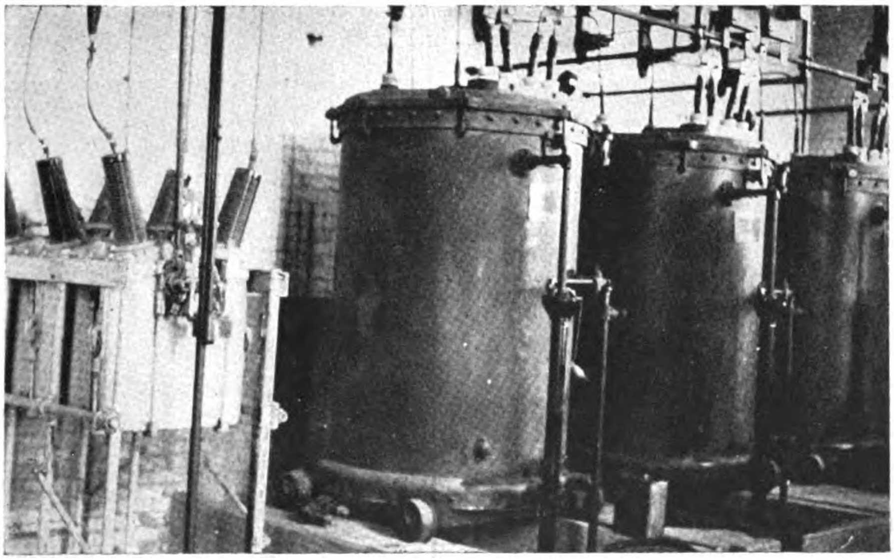


Fig. 5—These transformers step the voltage down from 22,000 volts to 575 volts for use on the various drives throughout the paper mill. The transformers are mounted on trucks and can be moved out from under the bus on a removable track which is not shown in the picture. The removable track section fits in the small recesses in the concrete shown in the lower right-hand corner of the illustration. Each transformer is mounted over a concrete catch basin which connects with the sewer, so that in case of an emergency the oil may be quickly drained.

clude the size, clay, alum and coloring. The average load is 30 hp. at 50 per cent lagging power factor. Most of the motors are used intermittently. Table X shows the list of motors.

In the beater room, all of the ingredients mentioned above, together with the various grades of pulp, are mixed ready for the paper machine. The average load is 275 hp., with a power factor of 85 per cent lagging. Table XI shows the motor list.

Part of the power for the machine room is a.c. and part d.c. The current for the direct-current motors is provided by a 250-volt, 200-kw., steam turbo-generator set. The paper machine is driven by the sectional Harland drive. The average load of the a.c. motors is 660 hp. at unity power factor and the list and ratings of these motors are found in Table XII.

The d.c. generator and motors which make up the Harland drive are separately excited from a 12.5-kw., 125-volt generator. The exciter and generator are both direct connected to the steam turbine through a 5½ to 1 reduction gear, as the speed of the generator and exciter is 900 r.p.m. Table XIII shows the duty and rating of the various sections of the drive. The master section of the sectional drive is shown in Fig. 6 and the couch section is shown in the lower left-hand corner of Fig. 1.

The dry end of the paper machine is equipped with three direct-current motors supplied by a motor-generator set, mentioned later. The list of these motors is given on page 367 in Table XIV.

In the finishing room, the paper is super-calendered, cut into various sizes and wrapped ready for shipment. Part of the motors are a.c. and part d.c. The average power for the a.c. load is 175 hp. at 77 per cent power factor. The list of motors is shown in Table XV.

Fig. 6 shows the layout of one of the super-calenders. There are two of these machines, each operated by a 75-hp. wound-rotor, induction motor. The control is full automatic, with three push button stations for each machine.

The direct-current motors shown in Table XIV as well as those in Table XVI are supplied from a 75-kw., 230-volt, direct-current generator, direct connected to a 110-hp. induction motor. This set, which is shown in Fig. 9, also supplies the excitation

Table III—Drive Data of the Wood-Preparation Department of the Sulphite Mill

Duty	No. of Motors	Type	Hp. Rating	R. P. M.	Drive
Chipper	1	S. C.	100	580	Belt
Chip conveyor	1	S. C.	20	600	Belt
Chip conveyor	1	S. C.	10	600	Belt
Crusher	1	S. C.	20	600	Belt
Chip screen	1	S. C.	20	600	Belt
Log conveyor	1	S. C.	20	600	Belt
Log conveyor	1	S. C.	10	600	Belt
Barking drum	1	S. C.	60	576	Belt
Barking drum	1	S. C.	60	865	Belt
Bark press	1	S. C.	15	860	Belt
Total	10	....	335	...	....

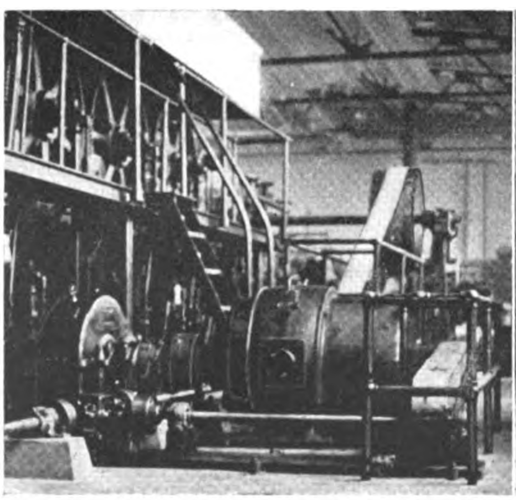
All of the above motors are three-phase, 550-volt, squirrel-cage (S. C.) induction motors.

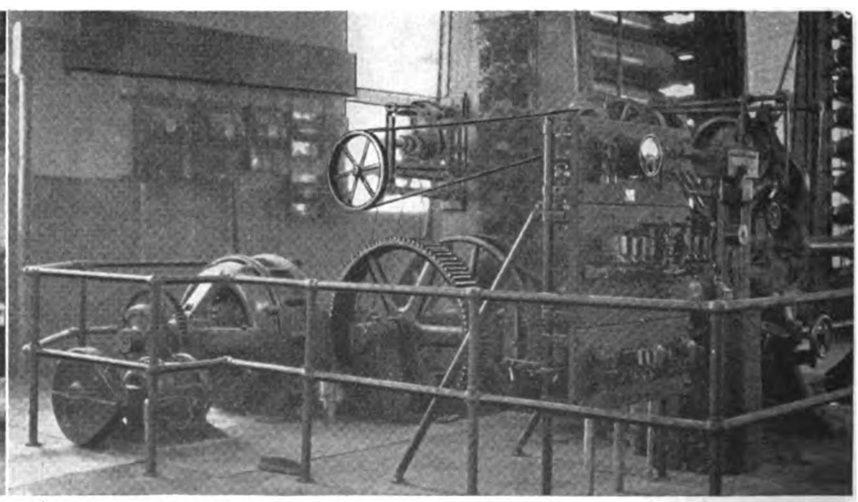
Table IV—Drive Data of the Acid-Making Department of the Sulphite Mill

Duty	No. of Motors	Type	Hp. Rating	R. P. M.	Drive
Acid pumps	5	S. C.	10	1,800	Direct
Gas fan	1	S. C.	12.5	720	Belt
Gas fan	1*	S. C.	10	1,160	Belt
Rock elevator	1	S. C.	10	1,200	Worm gear
Sulphur elevator	1	S. C.	3	720	Back-geared
Total	9	....	85.5	...	....

*Only used eight hours per week.
The last two items are used intermittently.
All of these motors are three-phase, 550-volt, squirrel-cage (S. C.) induction motors.

Fig. 6—Sectional paper-machine and super-calender drives.
In the illustration at the left is shown the master section of a sectional paper drive known as a Harland Drive. The illustration at the right shows a super-calender drive together with the full automatic control for it. A 75-hp. wound-rotor induction motor drives the super-calender.





for the Jordan motors. The average load on the motor-generator is 46 hp.

Steam-Plant and Water-Supply Motors and Drives

The motors in the steam plant are used in handling the coal, refuse, fuel and ashes, and for forced draft to the boilers. The list is shown in Table XVII. The average load on these motors is 75 hp. at 65 per cent lagging power factor.

The water used in the mill is pumped from a lake through two water systems: namely, a low-head and a high-head system. The water is pumped from the low-head station to a reservoir in the high-head station, one-third of a mile distant. The average load of the two systems is 415 hp. at 65 per cent lagging power factor. Table XVIII shows the list of motors.

Miscellaneous Motors and Drive Applications

This group is shown in Table XIX. The synchronous condenser is for power factor correction only, and while run continuously, could be dispensed with at times, since the power factor of the system as a whole, is high. If for any reason, the grinder motor or Jordan motors were to be shut down, however, the power factor would drop, and unless the condenser was put on the line immediately, the company would be penalized for low power factor. The actual load taken by this machine is the magnetizing load which amounts to about 50 hp.

Table V—Drive Data of the Sulphite-Pulp Process Department of the Sulphite Mill

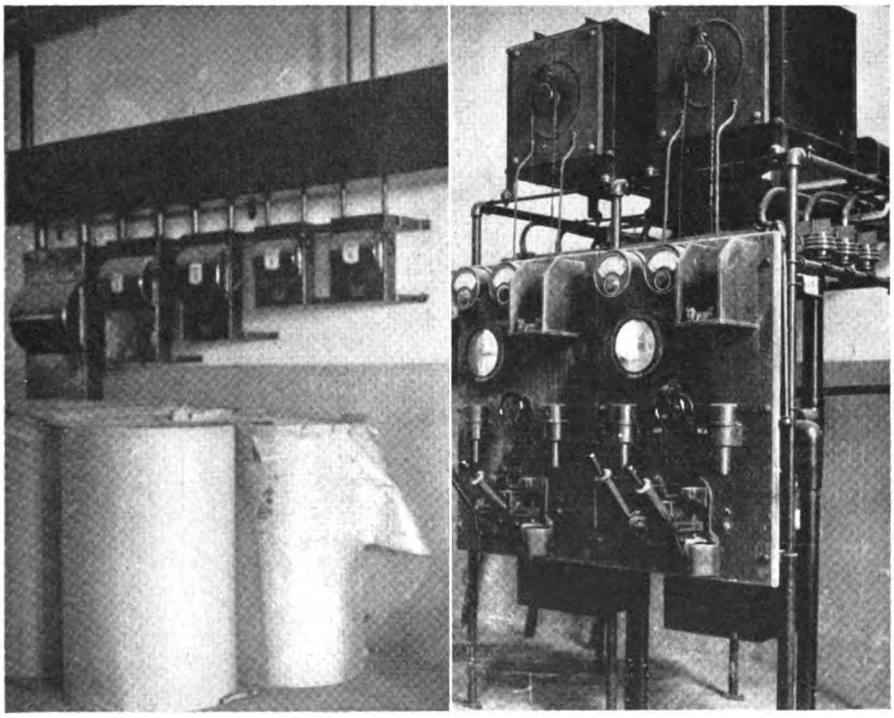
Duty	No. of Motors	Type	Hp. Rating	R. P. M.	Drive
Digester acid pump	1	S. C.	50	1,150	Direct
Booster pump	1	S. C.	40	1,800	Direct
Blower	1*	S. C.	0.3	1,725	Direct
Blow pit pump	1	S. C.	35	1,200	Direct
Knot screen	1	S. C.	35	860	Belt
Freight elevator	1	W. R.	20	860	Worm gear
Wet machines	1	S. C.	37.5	860	Belt
Flat screens	1	W. R.	75	720	Belt
Thickener	1	S. C.	7.5	720	Belt
Agitator and stuff pump	1	S. C.	65	720	Belt
Stock regulator	1*	S. C.	0.1	1,750	Gear
Stock pump	1	S. C.	35	1,200	Direct
Stock pump	1	S. C.	50	1,200	Direct
Save-all	1	S. C.	3	720	Back-geared
Save-all pump	1	S. C.	25	1,800	Direct
Hydraulic presses	1	S. C.	75	860	Belt
Stock agitators	1	S. C.	35	690	Belt
Sulphite packers	1	S. C.	10	720	Belt
Sulphite agitators	1	S. C.	50	720	Belt
Total	19	.....	648.4	...	....

*110-volt, single-phase, induction motors.
All other motors are three-phase, 550-volt, induction motors.
W. R.—wound rotor.
S. C.—squirrel-cage.

Table VI—Drive Data of the Screenings Plant of the Sulphite Mill

Duty	No. of Motors	Type	Hp. Rating	R. P. M.	Drive
Refiner	1	S. C.	50	1,160	Belt
Lap machine	1	S. C.	25	720	Belt
Total	2	.....	75	...	....

All motors are three-phase, 550-volt, squirrel-cage (S. C.) induction motors.



The portable air compressor is used for blowing out motors and keeping up the air pressure on the sprinkler system. It is used about two days a month. The 15-hp. compressor is used only for repair and construction work.

The concrete mixer is also for repair and construction work, and since it has not been used for a period of eight months, is not worth considering as a power load.

The machine-shop motor is used about nine hours a day, seven days per week.

The average load of this group is 70 hp. at unity power factor.

Fig. 7—The feeder is carried from the overhead line to the gutter box inside the building as shown.
From the gutter box, lines are run to the various motors, each line being controlled by a fused safety switch. The illustration at the right shows the control for the 250-hp. synchronous motors on the Jordan engines in the machine room of the *Book Mill.*

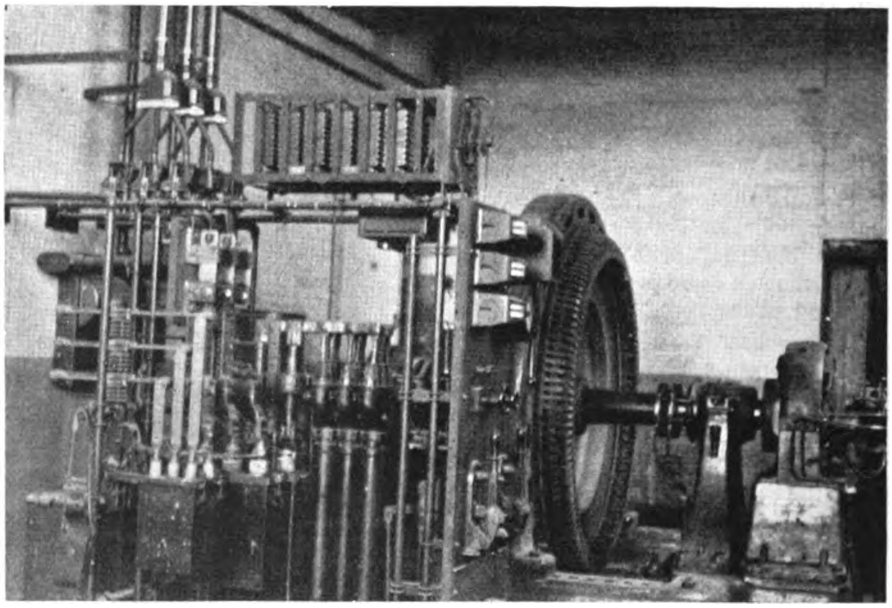


Fig. 8—Eight-hundred-horsepower synchronous motor driving two 3-pocket grinders which grind the wood into wood pulp in the ground-wood mill.

In laying out the various motor drives that have just been discussed there are three important points that have to be considered: Service or production is the main feature; maintenance or upkeep is the second; and last and least important is cost.

FACTORS GOVERNING THE USE OF DIRECT DRIVE

In the paper mills, the forms of drive commonly used are direct drive, gear drive, chain drive and belt drive. All are used, but there is a best place for each.

Table VII—Drive Data of the Wood-Preparation Department of the Ground-Wood Mill

Duty	No. of Motors	Type	Hp. Rating	R. P. M.	Drive
Slasher saw	1	S. C.	50	720	Belt
Disc barker	1	S. C.	10	600	Direct
Log conveyor	1	S. C.	10	720	Belt
Log conveyor	1	S. C.	15	720	Belt
Total	4		85		

All of these motors are three-phase, 550-volt, squirrel-cage (S. C.) induction motors.

Table VIII—Drive Data of Ground-Wood Pulp Process of the Ground-Wood Mill

Duty	No. of Motors	Type	Hp. Rating	R. P. M.	Drive
Grinders	1	Sync.	800	240	Direct
Deckers	1	S. C.	15	720	Belt
Stock pumps	3	S. C.	15	1,200	Direct
Pressure pump	1	S. C.	20	1,800	Direct
Rotary bull-screen	1	S. C.	3	1,200	Belt
Flat screens	1	W. R.	20	720	Belt
Exhaust fan	1	S. C.	1	1,200	Belt
Booster pump	1	S. C.	7.5	1,800	Direct
Agitators and thickeners	1	S. C.	75	720	Belt
Total	11		986.5		

All of these motors are three phase, 550 volt. Sync.—Synchronous motor. S. C.—Squirrel-cage induction motor. W. R.—Wound rotor induction motor.

Table IX—Drive Data of the Bleach Plant

Duty	No. of Motors	Type	Hp. Rating	R. P. M.	Drive
Liquor pumps and agitators	1	S. C.	35	1,200	Belt
Strong liquor pump	1	S. C.	7.5	1,800	Direct
Pumps and washers	1	S. C.	75	1,800	Belt
Bellmers	4	S. C.	40	720	Belt
Stock pump	1	S. C.	35	1,200	Direct
Stock pump	1	S. C.	25	1,200	Direct
Agitators and thickeners	1	W. R.	20	720	Belt
Total	10		357.5		

All of these motors are three phase, 550 volt.
S. C.—Squirrel-cage induction motors.
W. R.—Wound-rotor induction motor.

Table X—Drive Data of the Clay and Size Department of the Book Mill

Duty	No. of Motors	Type	Hp. Rating	R. P. M.	Drive
Size pump	1	S. C.	5	1,200	Direct
Clay conveyor	1	S. C.	5	720	Belt
Clay pump	1	S. C.	5	720	Belt
Clay elevator	1	S. C.	7.5	1,200	Direct
Clay conveyor	1	S. C.	15	600	Belt
Clay crusher	1	S. C.	20	600	Belt
Clay agitators	2	S. C.	7.5	720	Direct
Freight elevator	1	S. C.	6.8	1,200	Direct
Total	9		79.3		

All of these motors are three-phase, 550-volt, squirrel-cage (S. C.) motors.

Table XI—Drive Data of the Beater Room in the Book Mill

Duty	No. of Motors	Type	Hp. Rating	R. P. M.	Drive
Beating engines	2	W. R.	125	514	Belt
Triplex stuff pump	1	W. R.	25	720	Belt
Save-all pump	1	S. C.	10	1,200	Direct
Stock regulators	2*	S. C.	0.1	1,750	Gear
Total	6		285.2		

*110-volt, single-phase motors; the remainder are three-phase, 550-volt motors. W.R.—Wound-rotor induction motors. S.C.—Squirrel-cage induction motors.

Table XII—Drive Data of the Machine Room in the Book Mill

Duty	No. of Motors	Type	Hp. Rating	R. P. M.	Drive
Jordan engines	2	Sync.	250	360	Direct
Constant line	1	W. R.	150	600	Belt
White water pump	1	S. C.	35	1,200	Direct
Hood fan	1	S. C.	15	1,200	Direct
Paper slitter	1	S. C.	5	1,720	Belt
Booster pump	1	S. C.	75	1,800	Direct
Hytor pump	1	S. C.	10	1,800	Direct
Calender blower	1	S. C.	10	1,200	Direct
Paper drive blower	1	S. C.	7.5	1,200	Direct
Broke beater	1	S. C.	20	720	Belt
Total	11		827.5		

All of these motors are three phase, 550 volt.
Sync.—Synchronous motors.
W. R.—Wound-rotor induction motors.
S. C.—Squirrel-cage induction motors.

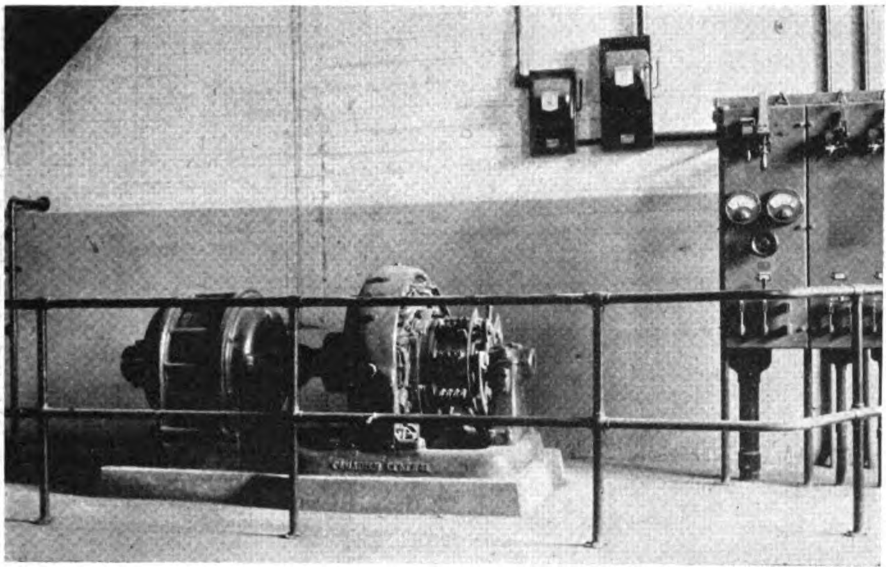


Fig. 9—This 75-hp. motor-generator set supplies the direct-current power for the motors in the dry end as well as the direct-current motors in the finishing end of the machine room in the Book Mill.

By the term direct drive is meant that the motor and the equipment it drives are connected through a coupling, without gears or auxiliary apparatus. It has been found more economical to drive centrifugal pumps by this method, since it not only does away with lineshafting and belts, but also makes the units independent.

In pulp and paper mills, it is no unusual thing to see from eight to ten, and even more motor-driven centrifugal pumps in one room. Some of these may be in line with each other, but more often they are installed to suit the piping layout. If these were driven from a lineshaft, they would necessarily have to be in line; otherwise, countershafting would be necessary. Probably the most important reason for choosing this type of drive is continuity of service. If all of the pumps in one department were driven from a lineshaft by one large motor, all operation and production would cease if a belt broke or came off, or a fuse was blown. With individual units, if one unit shuts down, it only ties up the particular machine the pump is feeding and consequently does not cause a serious production delay.

Another item to consider, but which is not as important as those mentioned, is the question of moisture. Where pumps are delivering and pumping to and from stock tanks, there is more or less liability of the tanks overflowing. Wet pulp in contact with a belt increases the slippage, and it is a common occurrence to have the belt run off the higher-speed pulley and thus interrupt operations.

In the case of plunger pumps, direct drive is not feasible and in most cases impossible, since with double- and triple-acting pumps, the driven pulley is between the pistons. While such a pump could be gear driven it would increase the cost considerably, and for this type of pump, belt drive is more economical.

Aside from centrifugal pumps, there are several other types of machinery with which the use of direct-connected motors is advantageous. For instance, where hand barkers are used, direct drive gives better balance to the barker, saves space, shafting and belting.

In driving fans and blowers, while it is not always possible to connect them directly to the motor, owing to the high rates of speed at which they travel, a fan unit takes up less space with direct drive than with any other type.

In the case of pulp grinders, owing to the (*Continued on page 400*)

Table XIII—Drive Data of the Harland Drive in the Book Mill

Duty	No. of Motors	Type	Hp. Rating	R. P. M.	Drive
Couch	1	Cpd.	55	585/720	Reduction gear
Presses	3	Cpd.	28	500/615	Reduction gear
Dryers	2	Cpd.	55	585/720	Reduction gear
Calenders	2	Cpd.	55	585/720	Reduction gear
Total	8		359		

All of the above motors have forced ventilation.
Cpd.—Compound wound.

Table XIV—Drive Data of the Dry End in the Book Mill

Duty	No. of Motors	Type	Hp. Rating	R. P. M.	Drive
Paper winder	1	Cpd.	20	400/1,200	Belt
Paper hoists	2	Sht.	4	1,100	Direct
Total	3		28		

The above motors are 230-volt, direct-current supplied from a 75-kw. M.G. set.
Cpd.—Compound wound.
Sht.—Shunt wound.

Table XV—A. C. Motors Used in Finishing End of the Book Mill

Duty	No. of Motors	Type	Hp. Rating	R. P. M.	Drive
Freight elevator	1	S. C.	6.8	1,200	Direct
Super-calenders	2	W. R.	75.0	720	Belt
Super-calenders	2	S. C.	10.5	900	Gear
Super-calenders	2	S. C.	3.0	900	Belt
Motor-generator	1	S. C.	110.0	1,200	Direct
Box mill	1	S. C.	7.5	720	Belt
Paper trimmer	1	S. C.	3.0	1,200	Belt
Total	10		303.8		

S. C.—Squirrel-cage induction motor. W. R.—Wound-rotor induction motor.

Table XVI—D. C. Motors Used in Finishing End of the Book Mill

Duty	No. of Motors	Type	Hp. Rating	R. P. M.	Drive
Rewinder	1	Cpd.	15.0	300/1,200	Belt
Sheet cutters	3	Sht.	7.5	450/1,350	Belt
Monorail cranes	2	Sht.	3.5	1,100	Direct
Paper hoist	1	Sht.	4.0	1,050	Direct
Total	7		48.5		

Motors are 230-volt, d. c. Cpd.—Compound wound. Sht.—Shunt wound.

IN THIS ARTICLE Mr. Richards outlines methods that are used to control from the main office the lubrication and inspection of a variety of miscellaneous equipment in nine widely separated bakeries, each of which would be equivalent to a moderate-sized factory. That this plan has worked satisfactorily here is evidenced by the fact that during the more than two years of its operation not a single motor or machine failure has occurred. Similar methods might be applied to moderate-sized factories.

Inspection Routine and Methods of

Controlling Industrial Lubrication

Of Miscellaneous Equipment in Nine Widely Separated Factories Together with a Discussion of Proper Lubricants.

By KEENE RICHARDS

Industrial Engineer, Grennan Cake Corporation, Detroit, Mich.

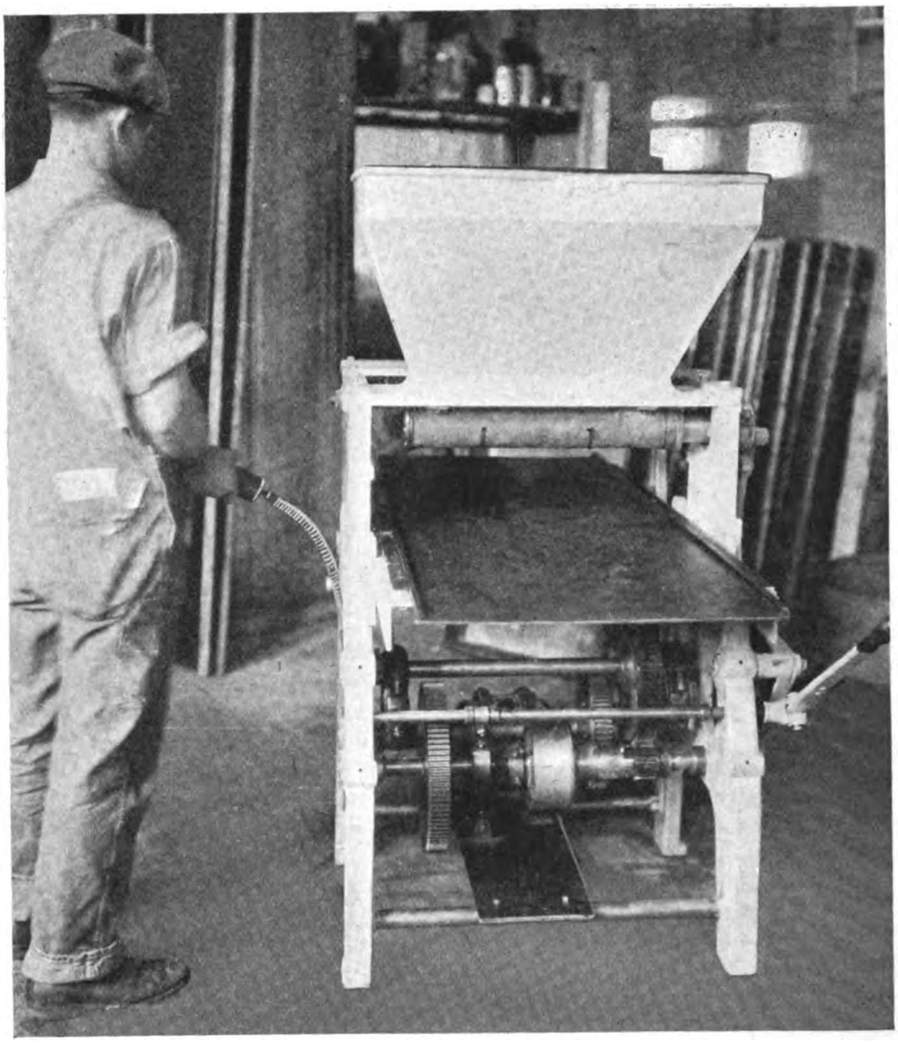


Fig. 1—Wherever possible these machines have been provided with nipples to use in connection with Alemite grease guns.

THE PROBLEM of correct lubrication of machinery and transportation equipment is, beyond question, one of the most important factors in the successful operation of present day industry. The large plant with its resident engineer and local maintenance staff is in the best position to properly solve this problem. However, when a property consists of a number of moderate-sized factories scattered over several states the difficulties of insuring proper lubrication at reasonable expense are greatly increased.

The following method has been in use in the widely separated plants of the Grennan Cake Corporation, located in nine different cities, for more than two years and has proven to be highly satisfactory. The *Engineering Department* is located with the general offices in the Detroit factory. This department has control of technical matters in all plants. In addition to the factory equipment, this department is responsible for the supervision of the maintenance of motor transportation. Machinery is in practically every case driven by individual motors, the majority of which are three-phase. In practically every case the machines are equipped with either variable speed transmissions or gear reductions between the motor and the equipment.

This machinery can be classified in a general way into the following groups:

(1) Machines for the handling of raw materials, such as elevators, conveyors, flour sifters and blenders, and sugar grinders.

(2) Mixing machines. This class of machinery consists of beaters for the mixing and aerating of batter, eggs, icing and other material of a more or less liquid nature. Mixers for the mixing and rubbing of heavy types of dough and special beaters for marshmallow.

(3) Scaling and deposition machines for placing dough in pans, depositing icing on cakes, cutting equipment for the cutting of cake and box forming and filling machinery.

(4) Ovens. These are of either horizontal traveling hearth variety similar to a conveyor, or of the rotary type in which a circular hearth travels in the baking chamber.

The problem of lubrication for each of these types of equipment is quite different. In the first class the conveying equipment offers no particular problem. It is lubricated in general with grease and the ordinary squirt can. In the grinding or chopping machines and the flour handling equipment, the principal difficulty is to keep the raw material, such as powdered sugar and flour, nuts, or other loose material from getting into the bearings. The manner of doing this varies with the type of machine. It is most easily done by keeping the bearing flooded with oil or keeping it under grease pressure so that dust from the machine will not creep into the bearing. In places where the bearings are so arranged that the oil would get into

the product, the only solution, aside from guards, which are more or less ineffectual, is the frequent cleaning of the bearings. Powdered sugar is very difficult to handle from a lubrication standpoint as it rapidly cuts out bearings and converts the lubricant into a sticky granular mess. For this reason the life of bearings in sugar grinders is apt to be short, unless special care is taken in cleaning.

Mixing machinery presents no particular difficulty except the necessary provision made by the manufacturer of the machine to keep the lubricant out of the mixture. The beaters are of the vertical type with the motor mounted at the rear of the machine about 3 ft. above the floor level and driving the machine through spur gearing and transmission which usually allows for three changes in speed. This transmission is lubricated with grease compound, the motor, of course, being ring oiled. The horizontal type of heavy-duty mixer is lubricated either by compression grease cups or drip feed oilers and as this equipment is comparatively slow speed, little or no difficulty is experienced with bearings, although the stuffing boxes though which the main beater shaft passes, occasionally give trouble and if not taken care of properly, will score the shaft.

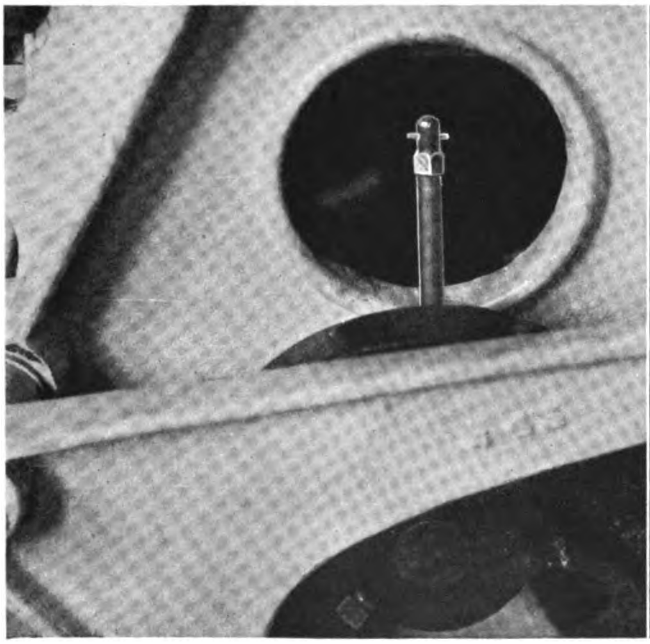
Machinery in Class 3 is ordinarily of light construction and is lubricated very easily by means of grease gun, grease cup and oil can. Much of this machinery is poorly constructed and inadequate provision is made for bearing adjustment. The illustration at the beginning of this article, Fig. 1, a detail of which is also shown in Figs. 2 and 3, shows how some of the natural difficulties of lubrication due to the construction of the machine may be overcome. On this scaling machine a cam, shown in its lower position, makes the oil opening difficult to get at and somewhat hazardous if it is oiled while the machine is in operation. The grease gun connection is raised above the cam by means of an extension pipe as shown in the detail, Fig. 2. This bearing was particularly difficult to lubricate by ordinary methods.

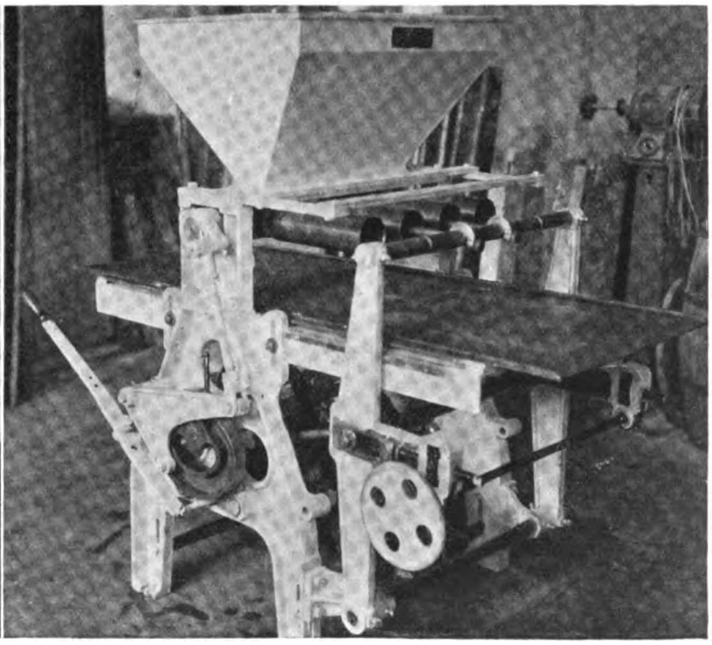
The principal difficulty experienced in lubricating the moving parts of ovens, Class 4, is the high temperature. This is provided for in the character of lubricant used as is noted later. Provision is ordinarily made in the construction of these machines to prevent lubricant getting into the food product handled. Some parts of machines, however, which are directly in contact with food, must be lubricated. This is taken care of by using shortening such as lard or hydrogenated cotton seed oil compound as a lubricant. Whenever equipment is laid up all parts which may come in contact with the product are coated with shortening and the other parts of the machine are doped with grease in the usual manner. It is important that lubricating oil or grease does not come in contact with the material in the machine. This is ordinarily prevented in the construction of the machine by the use of drip rings, felt packing and the placing of bearings so that should they leak, the oil will not drip into the mixing bowl or tank.

Machine and Motor Equipment Lubrication Routine

In each plant one man is made directly responsible for the daily lubrication and inspection of all bearings. After coming on duty in the morning this oiler makes a trip through the factory with oil can and grease gun. If the oiler finds anything wrong with the machine he reports it immediately to the factory maintenance man. In the case of the smaller plants the oiler and the maintenance man are frequently the same individual. Immediate attention is given to the trouble and an inspection report made out when the work is finished. It is assumed that an inspection is necessary in order to find the defect and that the inspection is not complete until the remedy has been applied.

Bearings requiring oil, not provided with automatic oiling devices, are lubricated with reclaimed engine oil. This oil is obtained by filtering the oil drained from the crankcases of motor vehicles. No attempt is made to remove the gasoline from this oil as the dilution is not only unobjectionable but is actually beneficial as it reduces the viscosity of the otherwise too heavy motor oil





Figs. 2 and 3—These illustrations show more closely the lubrication of the scaling machine in Fig. 1.

Because of the cam, as may be seen in the illustration at the right, this was a difficult place to lubricate. The solution was to extend the pipe up from the oil hole as shown at the left and add a nipple for Alemite lubrication. A little thought can often overcome many of the difficulties of properly lubricating equipment.

to a proper degree for light equipment.

Bearings lubricated with oil are generally on the Class 3 type of equipment and consist of small rocker arm shafts, operating infrequently and slow rollers on conveyors, light-duty cams and light eccentrics. Automatic oiling devices in the form of self-contained force feed oilers or the common drip oiler are provided for medium-speed bearings on some forms of horizontal mixers. These, however, in the more modern machines, are being replaced by self-contained, forced-feed oiling systems which keep the bearings flooded with oil. This applies particularly to heavy-duty bread mixers.

Reclaimed oil has been used successfully in electric motors, although it is felt that this service is too important and the duty required too heavy to use reclaimed oil, unless it were possible to test each batch coming from the filter for viscosity, specific gravity and percentage of high-volatile oil present. The oil wells of electric motors and other equipment having ring-oiled bearings are inspected for proper oil level and condition of rings; medium-body motor oil is used in oil wells.

Slow-speed bearings, rocker arms and other miscellaneous points requiring grease lubrication are equipped with nipples and lubricated by means of an Alemite grease gun. This method has been found much superior to the use of the ordinary grease cup. Common cup grease is used in this equipment. Bearings subjected to high temperature, such as main drives for traveling and rotary ovens, are lubricated with graphite grease or a mixture of automobile cylinder oil and graphite. This grease or oil is mixed to suit the particular condition of the individual bearing. Enough graphite is mixed with the cup grease so that it will remain stiff enough to prevent it from flowing from the bearing at the temperature at which it is to be used. Sufficient graphite is mixed with cylinder oil to keep the bearing well coated with graphite even though through inattention or for some other cause such as momentarily increased temperature the oil should evaporate or drain out of the bearing. It is impossible to give proportions used as they vary widely with each type of bearing.

Location Inspected	Oven #1 Inspected	Electric Inspected	Motor Inspected	Inspection Inspected
2-10-23	10-11-23	6-11-24		
3-10-23	11-10-23			
4-11-23	12-10-23			
5-10-23	1-11-24			
6-11-23	2-11-24			
7-11-23	3-10-24			
8-11-23	4-11-24			
9-11-23	5-10-24			

Motor No.1567959 Detroit

Fig. 5—Monthly motor inspection reports, Fig. 4, are recorded on this card.

When an inspection report is received at the *Engineering Department* in the Detroit office from any of the nine plants it is entered on the card for that machine. In this way it is easy to check whether any piece of equipment has been overlooked.

In rotary oven drives which are subjected to a temperature of about 400 deg. the grease merely serves as a means of getting the graphite to the bearing as the grease itself is soon melted out by the high temperature. In some cases oil and graphite are more effective as in any case the graphite is the lubricant. In general, the graphite-grease mixture is used on slow-speed, heavy-duty bearings and the oil-graphite mixture on small bearings of slightly higher speed. Either mixture may be used in the grease gun. In all cases where grease guns are used the bearing is filled with grease daily. A bearing of practically any type which has been giving trouble can very often be kept in service even though it is ordinarily lubricated with oil, by screwing in an Alemite grease cup, filling the grease gun with oil containing about 10 per cent of the finest grade of graphite and then forc-

PLANT Detroit GRENNAN CAKE CORPORATION

MOTOR INSPECTION REPORT

To the Industrial Engineer: Date 6-10-24

Electric Motor No. 1709489 Driving Mixer A112

Was on this date inspected and repairs made as noted.

Oil Dirty Oil Rings O.K. Clearance Low

Blownout ✓ Wiped ✓ Brushes None

Commutator or Rings None Leads O.K. Pulley or Gear O.K.

Insulation Poor Starter O.K. Fuses O.K.

Remarks: Insulation in bad condition due to spattering of dough. New Cover needed!

APPROVED J.H.A. SUPT. SIGNED G.G. MAINTAINENCE MAN

Form E103

Fig. 4—Monthly inspections and reports are made of all motors and sent to the Detroit office.

Motor inspections are all made by competent electricians. Periodic "spot" checks of these inspection reports are made on various pieces of equipment in the individual plants by the industrial engineer from the Detroit office. A record is taken from the office of the reported conditions and these are checked against the actual conditions found. A detailed report is made to the president of the company of these general plant inspections and the various plant officials have considerable rivalry between them on the rating which they receive as to the condition of their equipment, as found by the industrial engineer on his periodic check-ups.

E 101 8-21-1500

EQUIPMENT RECORD

Article Cookie Cutting Table.	Co. No. A265
Maker Welded Steel Barrel Co.	
Size 4 x 8	
Date Purchased 1-2-23	At Detroit
Estimated Life 5 yrs.	

Fig. 6—A record of all equipment is kept in the Detroit office.

This shows the manufacturer, the date purchased, the location and probable life. Any extensive repairs, change in location or disposition of this equipment is recorded here.

ing this oil through the bearing, thoroughly flooding it and washing it out. This can be done without shutting down the machine and is particularly effective where a grease bearing has become clogged by the introduction of foreign material, such as dust, into the grease.

Transmissions and gears are lubricated by grease compound similar to common, black, steam-engine cylinder oil. This compound is marketed as Warren Tru-Grease and 600-W. We prefer the first mentioned. This compound is sticky so that it is impossible for gears to plow a channel through the lubricant. In fact this grease is so sticky that it can be wiped from glass only with great difficulty. Gear cases are cleaned out twice yearly and thoroughly flushed with kerosene. Gasoline is not used, due to the fire hazard and because it is believed that it strips the metal completely of its oil film where kerosene itself has some slight lubricating properties and does not entirely destroy the film of lubricant on the surface of the metal. This grease is not worn out at the end of this time but is discarded to insure the removal of particles of metal.

Monthly inspections are made of all electric motors and reports made to the *Engineering Department* in Detroit on the form shown as Fig. 4. Upon receipt in the *Engineering Department,* this report is checked over and its receipt recorded on Fig. 5, which is placed in a card file. If this record shows a motor has not been inspected on time, the superintendent of the plant affected is notified at once. In this way it is impossible for a motor to be overlooked. If the motor inspection report shows indications of overload or any other serious trouble with the motor or machine, an investigation is made immediately and proper steps taken to replace the motor. As an instance, a beater driven by a 3-hp. motor had been running satisfactorily for about two years with no more than the usual inspection. The motor inspection report showed the insulation of this motor gave indications of overheating. An immediate investigation was made which showed that the character of the product mixed in the machine had been so changed as to materially increase the load on the motor. Immediate steps were taken to replace this motor with one of proper size.

All electrical inspections are made by a competent electrician. In the smaller plants where it is not possible to have an electrician as well as a machinist or maintenance man, it has been found advisable to hire an electrician and train him in general maintenance work rather than try to get outside assistance or train the average maintenance man in the care of electrical equipment. We have found that the average competent electrician is generally of higher average intelligence than the so-called all-around mechanic or maintenance man found in most plants.

At this inspection the clearance between the rotor and stator is measured to insure that bearings are not worn down sufficiently to cause cutting of insulation by the rotor. Oil wells are drained, flushed out, refilled and the motor thoroughly cleaned and inspected. Any repairs to insulation, oil rings, or brushes are made at this time.

In case any changes are made on motors, such as replacing leads, brushes or anything of that sort, this is considered as a special inspection and a report made showing the condition found and the condition left as in the regular inspection. Frequent visits are made to all plants by the industrial engineer at which time spot checks are made on various pieces of equipment in the plant. For this purpose a record is taken from the office as to the reported conditions

Figs. 7 and 7A—Motor records are kept on 3-in. by 5-in. cards like this.

Practically all information which may be required about any motor is maintained in the *Engineering Department* of the Detroit Office on these cards. A complete record of repairs or failures is entered on the reverse side of the card, as shown at the right.

GRENNAN CAKE CORPORATION—ENGINEERING DEPARTMENT

Maker Fish Oven *Style* Rotary ~~*Serial*~~ Motor *No.* 1567859

Size

Date Purchased 1-2-23 *At* Detroit, Mich.

Estimated Life 10 yrs.

Motor H. P. 1 *Make* G.E. *Speed* 1750 *Serial No.* 1567859

Phase 3 *Voltage* 220 *Diam Shaft* 3/4" ~~*Pulley*~~ *or Pinion*

Location	*Date*	*Remarks*
Fish Oven	1-2-23	Moved from Chicago plant

Machine Oven Rotary *Co. No.* A-110

REPAIRS AND FAILURES

Date	*Time Lost*		COST *Labor*	*Material*
6/15/23	2H 10M	Clutch Jaw Broke	3.60	2.40

which are checked against the actual conditions found. These general plant inspections are in each case followed by a detailed report to the president of the company. There is considerable rivalry between plants as to the rating which they obtain on the condition of their equipment as shown by these reports.

Motors installed vary in size from ½ to 50 hp.; the large majority of motors are, however, 3 and 5 hp. The larger motors are used on ammonia compressors for refrigerating equipment and heavy-duty bread mixers. We have standardized on General Electric or Westinghouse motors and do not accept machinery equipped with any other make. This has been done because it has been necessary to standardize on some particular make in order to simplify repairs. The two manufacturers mentioned are in a position to give us quick service on repair parts and maintain large stocks throughout the country. For these reasons we specify their equipment.

The most frequent repairs made to motors, and indicated as necessary by these inspections, are the cleaning of the motor including the air gap, cleaning of bearings, reinsulation of leads and replacement of bearings. Motor failures before this system was put in operation were principally caused by reduction of air gap due to the wearing down of bearings caused by dirty oil. The air of a factory producing baked goods contains a large amount of flour and sugar dust, which materially shorten the life of high-speed bearings. Proper oiling, cleaning and inspection entirely eliminate this hazard. It is interesting to note in this connection that with these regular inspections there has not been a single motor failure in nine plants, over a period of two years, since this system was put into effect. Previous to that time, motor failures were frequent.

Comprehensive Records Are Kept of All Equipment

In the office of the *Engineering Department* at Detroit a card file, Figs, 6, 7 and 7a, is maintained which records complete data on each electric motor, machine and automobile owned by the company. These cards show the date of purchase, location, size, manufacturer's and company's number and other information. Any extensive repairs or failures are recorded on the back.

These records enable the *Engineering Department* to intelligently recommend the purchase of new equipment, to determine the useful life of machinery, and to draw conclusions as to comparative operating conditions in different plants. Indirectly they serve as a check on the quality of maintenance work done in various factories.

Motor car lubrication is handled in a similar manner. Cars are oiled and greased each night by a competent oiler. Crankcases are drained at the end of each 500 miles, the oil reclaimed by means of a filter and issued for factory lubrication. The crankcase is not washed out with kerosene, as the use of kerosene is decidedly detrimental in that it breaks down the oil film established on the metal of bearings and cylinder walls. The same type of compound is used in rear axles and transmissions as is used in transmissions of machinery in the factory. Each thirty days a complete inspection is made of each car and a report sent to the *Engineering Department* at the main office on the form shown as Fig. 8.

Simple Laboratory Control of Lubrication Purchases

All lubricating oil and grease is purchased on specification. Analyses are made from time to time to see that the quality specified is secured.

This analysis also serves as a check on operating conditions in the factory and in the case of any difficulty with automobile lubrication serves to determine whether crankcase oil is being changed frequently enough. In case of trouble with lubrication of any bearings, whether on motor vehicle or factory machine, a sample of the oil from the bearing, accompanied by a fresh sample of the oil used (*Continued on page 401*)

Form G-102 1m 10-22 GKB

GRENNAN CAKE CORPORATION

Car Inspection Report

Date .... Car No. ....
Started .... Job No. ....
Stopped ....
Hours Labor .... ________ Plant Date of Last Insp. ....

1—Adjust and lubricate front wheel bearings		20—Lubricate brake levers and clevis pins	
2—Test front wheels for alignment		21—Tighten battery terminals, fill battery with water	
3—Change oil in engine		22—Tighten battery clamps	
4—Tighten engine holding down bolts		23—Tighten all electric connections	
5—Tighten and oil hood fittings		24—Tighten gasoline tank	
6—Tighten and oil body bolts		25—Tighten rim bolts	
7—Tighten and oil all fender bolts		26—See that foot and hand throttles open and close carburetor	
8—Tighten windshield anchor bolts		27—See that fan belt is tight and pulley oiled	
9—Tighten instrument board bracket bolts and screws		28—Test gasoline line for leaks	
10—Test clutch for grabbing and slipping		29—Test horn	
11—Inspect torque arm and lubricate		30—See that generator is charging and oiled	
12—Lubricate clutch control lever and thrust bearing		31—See that distributer points are set properly	
13—Lubricate transmission		32—Adjust and equalize brakes	
14—Lubricate universal joints		33—See that pedal clear floor boards	
15—Lubricate springs		34—See that all lights operate	
16—Adjust and lubricate spring shackle bolts		35—See that doors open and close freely and that latches operate	
17—Test and lubricate steering gear		36—Test valves, ignition and carburetion	
18—Lubricate differential		37—Fill radiator and gasoline tank	
19—Inspect and adjust motor bearings		38—Clean and polish car for delivery	
		39—Varnish if needed	

REGULAR EQUIPMENT

1—Starting Crank		4—Jack	
2—Keys for switch		5—Rim Tool	
3—Extra rim or wheel		6—Side Curtains	

REPLACEMENTS MADE

Name of Part	Condition Found	Cost of New Part	Disposition of Old Part

Road test of 1 mile made by ________ and operation found satisfactory.

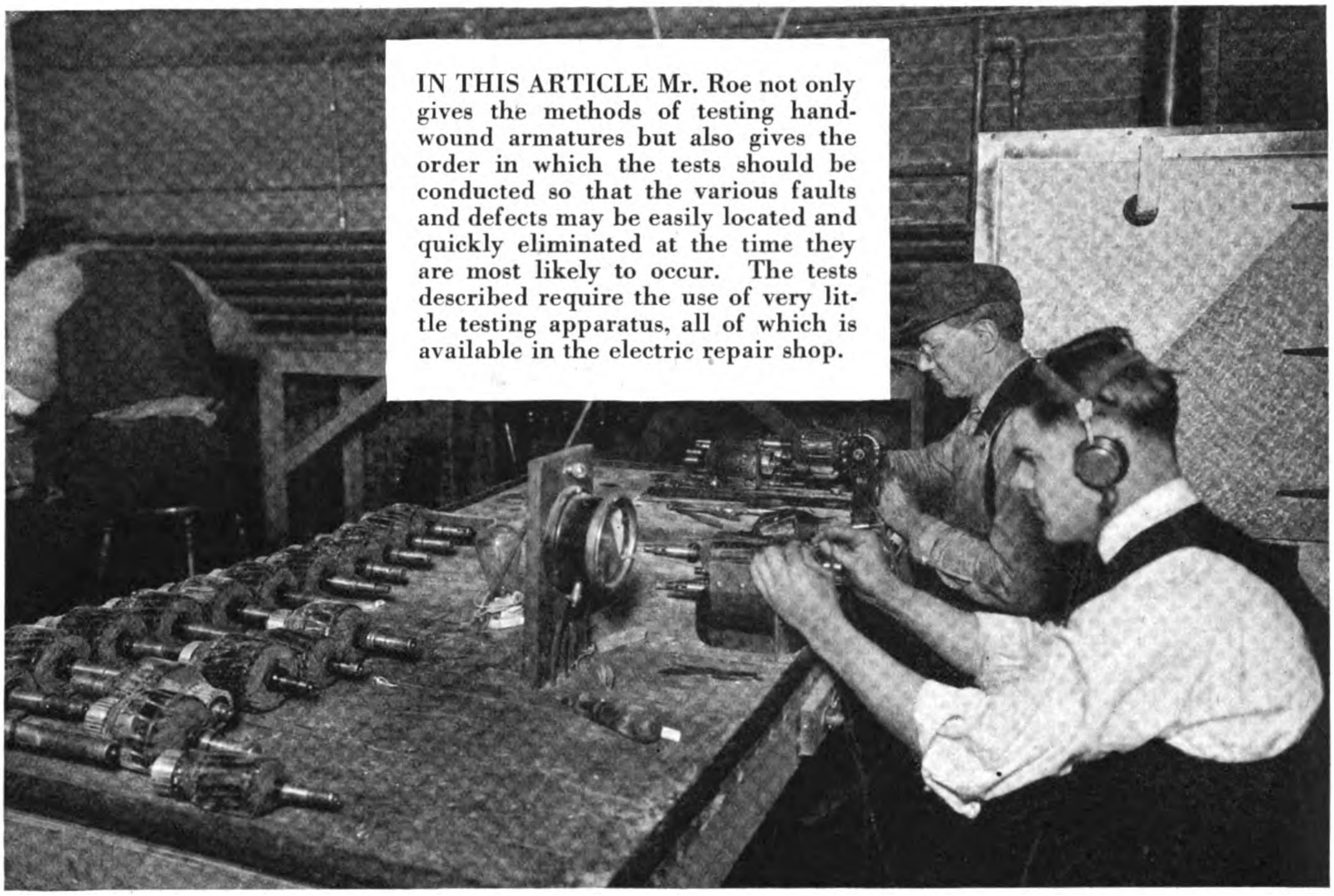
REMARKS:

Signed ________ Mechanic

Noted and Filed ________ Industrial Engineer

Approved ________ Supt. Trans.

Fig. 8—Motor cars of the various plants are also inspected monthly and their condition reported on this blank form.



IN THIS ARTICLE Mr. Roe not only gives the methods of testing hand-wound armatures but also gives the order in which the tests should be conducted so that the various faults and defects may be easily located and quickly eliminated at the time they are most likely to occur. The tests described require the use of very little testing apparatus, all of which is available in the electric repair shop.

Here is an arrangement of a test bench for armature testing.
The millivoltmeter is mounted on an upright wood panel, the test light is a little behind and to one side of it, and the growler is directly in front of the tester.

Some Practical Pointers on the Methods of

Testing Out Armatures During Rewinding

Together with Ways to Locate Shorts and Grounds in Armatures and Commutators Including Methods of Finding Reversed Leads and Shorts Between Coil Turns, Between Top and Bottom Coil Halves and Between Leads

By A. C. ROE

Repair Superintendent, Detroit Service Dept., Westinghouse Electric & Manufacturing Co.

ON HAND-WOUND armatures the wire is wound directly from the wire reel into the slots of the armature. Hand-wound armatures are used in fractional-horsepower motors such as fans, small drills, grinders, starting and lighting units, domestic-appliance motors and the like. In rewinding all types of hand-wound armatures there are a number of defects that can occur, such as grounds, reversed leads, open circuits, and short circuits between bars, between leads, between turns, between top and bottom coils and between coil ends. This last type of short circuit cuts out groups of coils.

In order to detect any of these defects while winding an armature as soon as possible after the defect occurs, it is well to have a procedure of testing that will perform this function. The following method of testing armatures is recommended for use in repair shops rewinding the average range of small armatures:

1. After the armature has been stripped and before winding, test the commutators for grounds and shorts.
2. Wind and wedge the armature.
3. Test for grounds and shorts, using a growler to locate them.
4. Connect the armature and then before soldering leads to the commutator, make a bar-to-bar test using a voltmeter.
5. Solder leads, dip and bake, and turn commutator.
6. Give the armature a final bar-to-bar test.

The reason that a bar-to-bar test is recommended after connecting and before soldering the leads, is that shorts between leads, as well as reversed and crossed leads occur at this stage, and it is easier to raise the leads to locate and remedy the defects when the leads are not soldered. The reason for the test after finishing the armature is that when soldering and turning the commutator particles of solder may run down between the bars at the back of the commutator, thus shorting the bars,

or in turning the commutator the tool may drag small particles of copper across the mica which also shorts the bars.

The first step after the armature has been stripped, and before winding, is to test the commutator for grounds and shorts. To test the commutator for grounds a piece of bare copper wire is wound around the complete commutator, making sure that the wire touches all bars. Apply one test lead to the shaft or core and the other to the wire around the commutator, as shown at *A*, Fig. 2. For armatures up to and including ½ hp., a test to ground of 900 volts, alternating current for one minute is sufficient. For armatures above this size, use twice the line voltage plus 1,000 volts for the test to ground; that is, for 100- to 150-volt armatures the test voltage is 1,200 volts; for 250- to 275-volt armatures the test voltage is 1,500 volts; for 400- to 450-volt armatures, use 2,000 volts. This test should be applied for one minute.

The next step is to test and clear the commutator of shorted bars. This is done with a 110-volt test lamp, putting the leads of the test lamp on adjacent bars as at *B*, in Fig. 2. The carbonized mica will glow or sputter depending upon the resistance of the shorts; in some cases of dead short, the test light will come up to full brilliancy. Most short circuits between bars can be cleared by digging out the dirt and carbonized mica with a knife or ground hacksaw blade. The hole should then be filled with a good commutator cement. A good cement can be made from plaster of paris and shellac. These two ingredients should be mixed together into a thick paste, which can be used to fill the hole in the commutator. Where there are a number of bad spots it will be found more satisfactory to put in all new mica segments or in the smaller sizes of motors, to supply a complete new commutator. The important thing is to be absolutely sure that the commutator is free from all defects before starting to wind.

In rewinding hand-wound armatures, a variety of cores and sizes are received. The condition of the cores varies; some cores are well insulated and others are hard to insulate properly. On some cores the slot or end room is scarce and considerable pounding is required to get the wire into place. When fine wire is used, there is a chance of its breaking; therefore, a 110-volt test lamp should be provided at the winder's bench or winding machine so that the winder can test each coil as he finishes it, thus detecting grounds or opens before passing the defect.

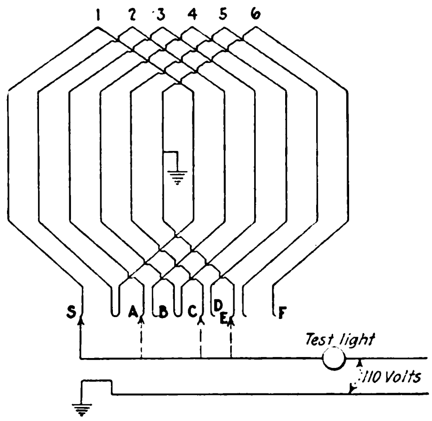


Fig. 1—How to locate grounded lead in straight loop winding, before connecting leads in commutator.

After cutting open the loop *A B*, if the test light glows with test lead on *S*, the ground is in section *S* to *B*. If light remains dark move test lead to *A*, *C*, and *E*, consecutively, cutting open loops about four slots ahead so as to sectionalize winding until grounded section of winding is found, as at *E*.

If the armature shows a ground, after winding and wedging and before connecting the leads to the commutator, the following procedure should be used for locating the grounded coils. There are two cases: one is the straight loop winding in which the wire is not cut from the start to the finish of the winding, and in the other case, each slot has a number of leads projecting from it, half of these leads being top or finishing leads, the others being bottom or starting leads.

In the case of the straight loop winding, the set-up shown in Fig. 1, should be used to locate the grounds. One test lead is fastened to the core or shaft and the other test lead is touched to one end of the winding as at *S* in Fig. 1. Then a loop about four slots away is cut open as at *B*. If the ground is in the section between *S* and *B*, the test lamp will not go out. If the ground is in the other section of the winding, the circuit will be broken and the light will go out. In this case, touch the test lead to *A*, cut open a loop four slots away, as at *D*. Repeat until the ground is located in a section of four coils, then starting with the first coil of this section, cut open the loops until the grounded coil is found. In Fig. 1, coil 6 is the grounded coil After locating this coil, the remainder of the loop winding should be tested to make sure that there is only one defective coil.

In the other case referred to, each slot has a number of leads projecting from it, half of them being top or finishing leads, the other half being bottom or starting leads. The first step is to separate the top leads and bend them back, toward, but not touching the core. The bottom lead should be pulled out straight and about ¼ in. of the insulation should be removed from the end of each lead. Then tie the leads together into separate bunches by pieces of bare copper wire and apply high voltage between each of these bunches and ground. One of these bunches of wire will show a ground. Remove the tie wire from the bunch that shows a ground and test each lead separately with a test lamp, one lead of which is on ground, until the grounded coil is found.

If the winding is tested for grounds after wedging and before

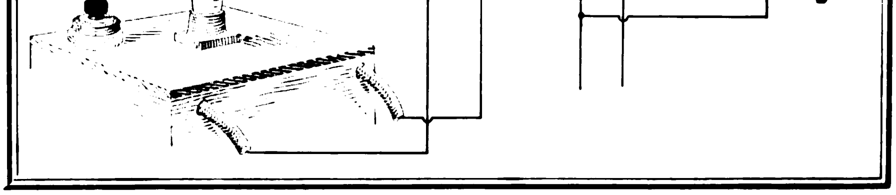


Fig. 2—To test a commutator for grounds, wrap a bare copper wire completely around it, making sure that the wire touches all bars.

This test is shown at *A*. Apply one test lead of the testing transformer to the shaft or core and the other to the wire around the commutator. At *B* is shown the method of testing a commutator for shorts between bars. This is done by putting a 110-volt test light in series with one lead from the power supply and applying the leads to adjacent commutator bars. If the bars are shorted the light will glow.

connecting to the commutator, the finished armature should be clear from grounds. However, if the winding shows a ground after connecting the leads to the commutator, the following method will locate the defect.

The set-up for this test is shown in Fig. 4. The test line with a lamp bank in series with it is connected to bars directly opposite, as at *1* and *10*. With a millivoltmeter on two adjacent bars at *2* and *3* adjust the lamp bank until approximately one-quarter scale reading is obtained on the meter. Then remove the millivoltmeter leads from bars *2* and *3* and connect one lead to the core as shown. With the other lead touch the commutator at a point midway between the two line leads, as bar *4*. Make this connection lightly and quickly, watching the meter scale. If the pointer of the meter goes off the scale try bar *5*, bar *6*, *etc.* If this does not bring the pointer down on the scale, try bars on the opposite side of bar *4*. The reason for the high reading when the meter leads are touched to bar *4* is as follows: Coils *1, 2, 3, 4, 5, 6, 7, 8* and part of *9* are in series to ground; hence the meter measures the drop across the series of coils between bar *4* and ground. When the meter lead is moved to bar *5*, as at *C*, the drop is reduced by one coil. As the lead is moved toward the bar to which the grounded coil connects, the meter readings will become lower until bar *9* is touched. This will give the lowest reading. If bar *10* is touched the reading will become larger. Decreasing readings indicate that the grounded coil is being approached while increasing readings denote that we are working away from the defective coil.

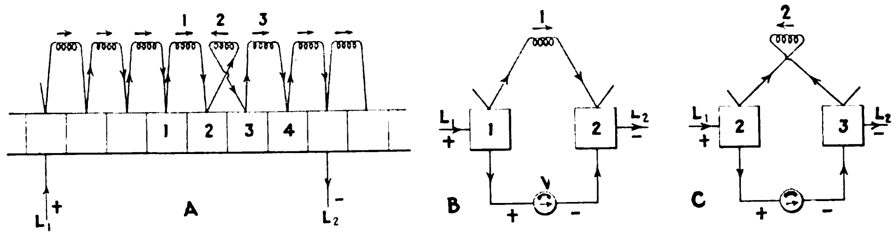


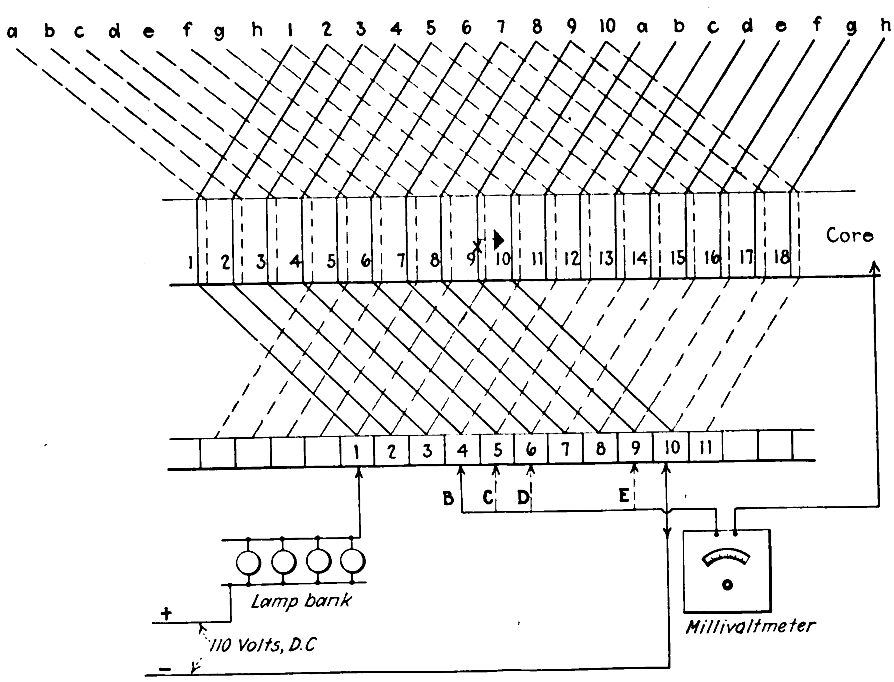
Fig. 3—Case of reversed leads that will not show up with the drop-of-potential or millivoltmeter test.

In diagram *A* is shown the connections for the ordinary millivoltmeter test. Current goes in commutator at L_1 and out at L_2. The current goes in the same direction through all the coils except coil *2*. With the millivoltmeter across bars *1* and *2* as shown in diagram *B* a deflection will be obtained. With the millivoltmeter across bars *2* and *3* as shown in diagram *C*, a deflection in the same direction will be obtained. Although the current through the coil is reversed, the millivoltmeter reads the same as in the case of coil *1* because it merely measures the drop of potential across the coil and not the current passing through it. The correct way to locate reversed leads is by the use of a compass as explained in the text.

After locating the grounded coil in the manner just described, test it by disconnecting from the commutator the top lead of the grounded coil and a lead on each side of this lead. Test the coil to ground and also the other section of the winding to make sure that all grounds have been located. A telephone receiver can be used in the test described, in place of the millivoltmeter. A loud noise in the telephone receiver corresponds to a high meter reading.

Fig. 4—Locating a ground by using a lamp bank and a millivoltmeter.

The millivoltmeter is first placed across two adjacent bars, as bars *2* and *3*, and the lamp bank adjusted so as to permit current enough to pass through the winding to give a quarter-scale deflection on the millivoltmeter. One lead of the millivoltmeter is then grounded to the core as shown and the other test lead is successively connected to commutator bars *4, 5, 6*, etc., as at *B, C, D*, respectively. As the bar to which the grounded coil is connected is approached the millivoltmeter readings will decrease and as we work away from the grounded coil the readings will increase. The lowest reading indicates the bar to which the grounded coil is connected.



Reversed or crossed leads often occur while connecting the leads to the commutator; hence these defects should be located before soldering the commutator connections. There are two cases of reversed leads: In one case a voltmeter will show up the fault; in the other case it will not. In diagrams *A*, *B* and *C* of Fig. 3 is shown a reversed coil or a case in which the top and bottom leads have been interchanged. In diagram *A*, the flow of current from the test leads L_1 and L_2 is from left to right through all the coils except coil *2*, over which the arrow is shown reversed. The only way in which this type of reversed lead can be detected is by means of a compass.

Inspection of diagrams *B* and *C*, Fig. 3, will show that a voltmeter or telephone receiver will not locate this fault. Using a millivoltmeter in the bar-to-bar test, as in diagram *B* of Fig. 3, place the millivoltmeter leads on bars *1* and *2*. This measures the drop over one coil, the direction of the flow of current being indicated by the arrow through the meter in the diagram. With the millivoltmeter leads on bars *2* and *3* as shown in diagram *C*, the drop over coil *2* is measured. In this case, the current through coil *2* is reversed, but the flow through the meter remains the same; therefore, there is no indication of trouble. If an armature with a coil in this condition were put in a motor frame and run, the coil would cause sparking every time it passed from under the brush. The correct way to locate this kind of a defect is to place a compass over the armature slot while direct current is being passed through the windings. The armature should be revolved slowly and as the slot having the defective coil passes under the compass, the compass needle will reverse. This trouble can be caused by the winder putting on the wrong colored sleeve

on the start and finish of one coil; that is, by interchanging colors.

Another case of reversed coil or crossed leads occurs in loop windings and is caused by putting the wrong colored sleeves on two loops. This case is shown in diagrams *A*, *B*, *C* and *D* of Fig. 6. In diagram *A*, the bottom lead of coil *1* and the top lead of coil *2* have been connected to bar *3*, and the bottom lead of coil *2* and top lead of coil *3* have been connected to bar *2*. This reverses coil *2* as is shown by the arrows over each coil. When making a bar-to-bar test with the millivoltmeter leads on bars *x* and *1*, the drop over one coil (coil *x*) will be obtained. Call this a normal reading. When the meter leads are put on bars *1* and *2*, a reading that is twice normal will be obtained, but the pointer will point in the same direction. Diagram *B* shows the reason for this double reading. The top lead of coil *1* connects to bar *1*, and its bottom lead to bar *3;* the top lead of coil *2* also connects to bar *3*, and the bottom lead of coil *2* is connected to bar *2*. Hence, coils *1* and *2* are in series between bars *1* and *2*. When the millivoltmeter leads are placed on bars *2* and *3* as in diagram *C*, the drop of one coil (coil *2*) is measured and a normal reading is obtained, but the pointer points in the opposite direction. The reason for the reversed reading is that the lead of coil *1* makes bar *3* positive, just as if L_1 were directly attached to bar *3*. When the millivoltmeter leads are put on bars *3* and *4*, as in diagram *D*, a reading of twice the normal amount and in the correct direction will be obtained. This is because coils *2* and *3* are in series between bars *3* and *4*. Hence, when making a bar-to-bar test, this type of defect is indicated by obtaining the following sequence of readings: first a double reading, then a normal but reversed reading and finally, a double reading in the proper direction. A telephone receiver would give a high, followed by a low, and finally a high sound. The meter is more accurate, however, as it gives one more indication; that is, the direction of the current flow.

The remaining types of defects that are likely to occur while winding and connecting armatures, are short circuits. Each type of short circuit has different characteristics and different methods must be used for locating them. The most common short circuit is a short between turns; that is, when one or more turns form a closed circuit. This affects only one coil. Using a millivoltmeter in the bar-to-bar or drop-of-potential method of testing, a short circuit between turns in a coil will give a lower than normal reading on the millivoltmeter scale. The magnitude of the reading depends upon the amount of the coil that is shorted out. A zero reading will be obtained when the coil is completely short circuited, in other words a dead short.

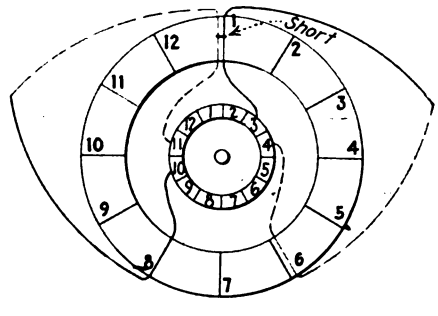
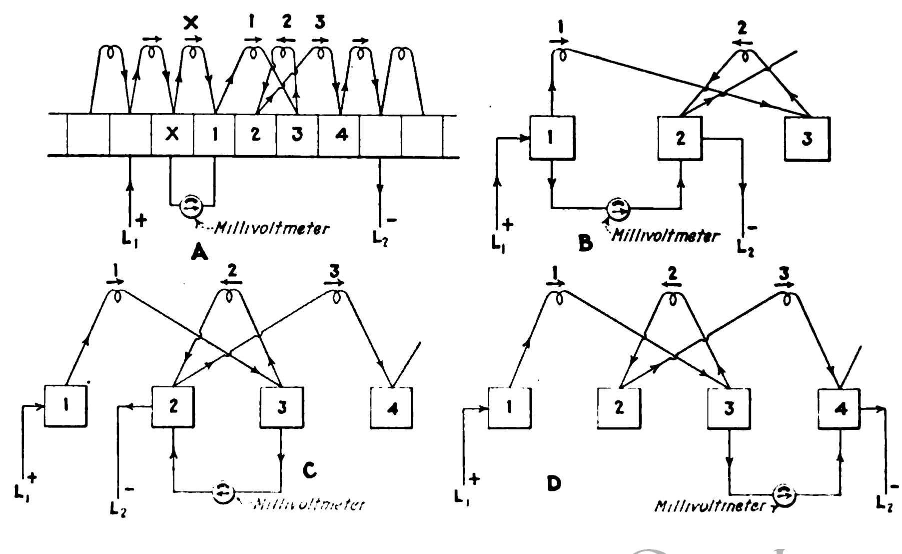


Fig. 5—Method of locating short that occurred between top and bottom halves of coils in the same slot.
In the growler test the tin keeper was attracted in slots *1*, *6* and *8*. The coil pitch of the winding shown is 1-and-6. Take any slot which has shown signs of being shorted in the growler test, for instance slot *1*. Then count each way from this slot a distance equal to one coil pitch and if the two slots reached are the remaining ones that showed signs of being shorted from the growler test, the two coils are shorted together in the slots from which the count was started. Counting a coil pitch each way from slot *1* we reach slots *6* and *8* which were the other two slots which showed signs of being shorted; hence the short between the two coils must be in slot *1*.

The best method of locating shorted coils is to use a growler. An armature should be tested for short circuits by means of a growler after winding and wedging and before connecting the commutator leads to the commutator. Then any shorts that show up after connecting are either in the commutator leads or in the commutator. When using the growler, shorts between turns will cause the metal keeper to be attracted to two slots; that is, the slots in which the top and bottom halves of each coil lie. By studying the effect of each type of short separately, it soon becomes easy to determine and locate any shorts that may occur in the winding. For example, assume a 14-slot armature, coil pitch 1-and-7 and that the growler test shows signs of shorts in four slots. Assuming that the coil turns are shorted and that the slots marked from the growler test are spaced 1, 4, 7, and 10, then slots *1* and *7* contain one coil and slots *4* and *10* contain the second coil. The coil pitch and what can be seen of the coil helps to locate the bad coil. With the bar-to-bar test the millivoltmeter will give a low reading when it reaches the two bars to which the lead of the shorted coil connects. This locates the coil without any further test. Shorts between coils in the same cell in a loop winding would come under the head of shorted turns, although the shorts are between coils, and if the two loops from the slot were cut open a light would be obtained between the two coils, although the circuit had been broken.

The next type of short is one that

Fig. 6—Another case of reversed coil leads that sometimes occurs in loop windings.
This condition is shown in diagram *A*. On passing a current through the winding and with the millivoltmeter leads across bars *x* and *1* as shown in diagram *A*, a normal deflection will be obtained on the meter. With the meter leads on bars *1* and *2* as shown in diagram *B*, a reading twice normal will be obtained, because the meter is across coils *1* and *2* in series. With the meter leads on bars *2* and *3* as shown in diagram *C* a reversed reading will be obtained. The reason for the reversed reading is that the lead of coil *1* makes bar *3* positive just as if L_1 were directly attached to bar *3*. When the meter leads are placed on bars *3* and *4* as shown in diagram *D* a reading twice normal and in the correct direction will be obtained. This is because the meter is measuring the drop of potential over coils *2* and *3* in series.

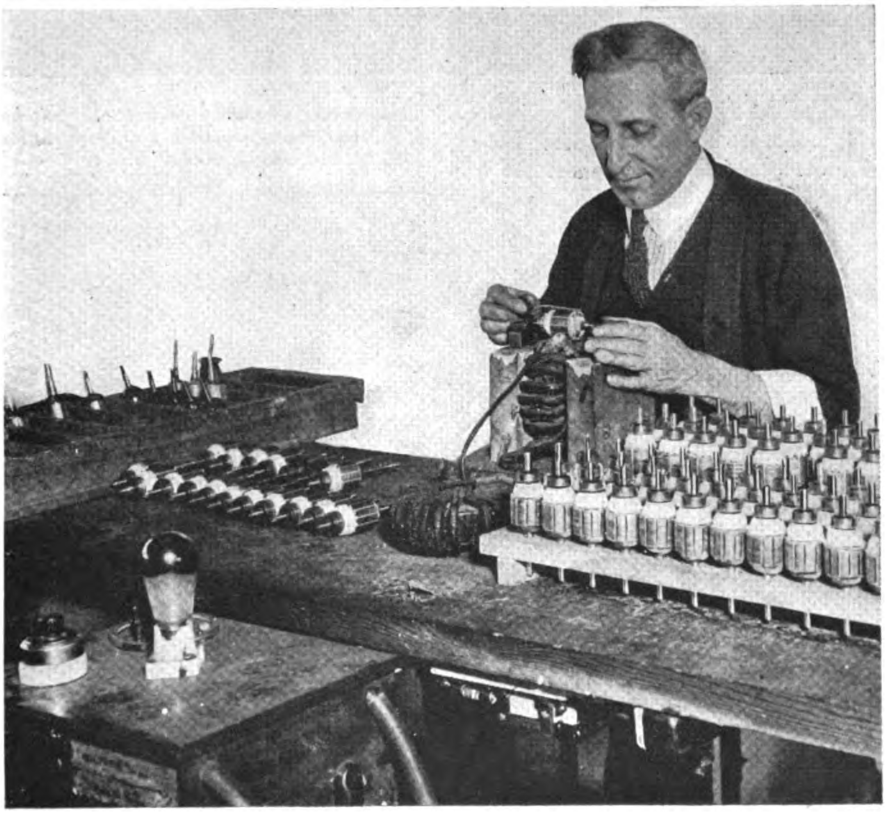


occurs between top and bottom halves of coils in the same slot; this is commonly called a short between top and bottom coils. This is done to distinguish this type of short from the short between the coils in the same cell in a loop winding. This type of short forms a closed path, similar to a figure 8 and will affect two and three slots, depending upon the type of winding and the coil pitch. With a diametrically-split winding, two slots directly opposite would be affected. With the chorded-loop, split-loop, and split-V-loop windings, three slots would be affected. To find the slot in which the short is located, take any one slot that the growler shows as shorted and calling this slot No. 1, count over to the right and to the left a distance equal to one coil pitch. Then if each count falls on a marked slot as shown from the growler test, the short is in the slot called No. 1, but if the count does not fall on a marked slot on both sides, take any other marked slot and call it No. 1 and repeat the right and left count. This method is shown in Fig. 5. With the bar-to-bar test, a low reading will be obtained between bars *10* and *11*, and *3* and *4*, but this would not indicate anything more than that there were two shorts in the winding. From the above, it is obvious that the growler is the best means of detecting and locating shorts. The growler will also show whether a short is in the winding, or in the commutator. If two commutator bars show up as being shorted from the millivoltmeter test, put the armature on a growler and bridge the two bars with a knife, taking care that the coil to which these bars connect is in the active field of the growler. Then break contact with one bar. If a spark is seen at the time of breaking contact, the short is in the winding; if no spark is obtained, then the two bars are shorted and the trouble is in the commutator.

Shorts between leads occur mostly on armatures that are wound with more than one wire in hand and in which more than one wire is used per sleeve. Shorts of this kind are caused by the wires in the sleeve getting twisted. When pounded on while connecting, the insulation is broken, thus shorting the two coils. This acts the same as a short between turns.

This trouble occurs mostly in the top layer of leads, for the bottom leads are usually put down as they come from the slot. The top leads have to be twisted and interchanged and sometimes the twist is pulled back close to the core. The very act of pulling the twist tight often results in a short. This type of short is one that occurs between coil ends on any type of hand winding and is the hardest type of short to locate because one coil in crossing the end of the core from slot to slot, passes over a number of other coils, both top halves and bottom halves. There is no regularity about the occurrence of the attracted slot or bars when using the growler. A number of slots will show signs of shorts and they cannot be reduced to a regular order as explained previously. You can be sure that the trouble is between coil ends, sometimes, by moving the end windings with the hand. If the trouble can be made to disappear and reappear, this proves where the trouble is, but if this method fails the following will locate the trouble: Remove all the top leads; then take a test light and attach one lead of the test circuit to any one top lead with a piece of bare, copper tie wire. Have this wire long enough to reach around the commutator. Then with the other test lead touch the top lead adjacent to the one to which the first test lead is permanently attached. If a light is obtained, it indicates a short between these two coils. In this case, tie the two leads together with the tie wire and at the same time mark both leads so they can be found later. If no light is obtained, tie both top leads together with the tie wire without marking the leads. Then touch the test leads to the next top lead. After this tie this lead to the first two leads by the tie wire. Repeat this process with each top lead until the starting point is reached, marking every top lead that shows a light. These marked leads are the ones that connect to the coil shorted across the coil ends. With a bar-to-bar test, all kinds of readings would be obtained on the millivoltmeter, depending on the degree of contact and the number of places shorted. No definite results would be obtained with a bar-to-bar test in this case.

Fig. 7—Using a growler to test a small armature for shorts.
If the tin keeper which is placed over the top slot is attracted, the coil in that slot is defective. In the foreground at the left is a portable testing transformer which is used for testing the winding and commutator for grounds.



The foregoing discussion applies to hand-wound armatures only, that are being rewound. When a number of troubles show up in a winding and they give trouble in locating it will be found the best policy is to strip and rewind the armature completely.

From the above, it follows that with the drop-of-potential or bar-to-bar test, a short circuit in a coil will give (*Continued on page 401*)

WITH THE ENLARGEMENT of existing departments or the addition of new ones and the increasing use of power service, the original distribution system of a factory or institution often becomes inadequate. Unless the necessary additions to the system are well planned and carefully installed, the result is a system which is cumbersome, inefficient and perhaps hazardous from fire and safety standpoints. In this article, Mr. Fritz describes a distribution system, in which safety for operators and reliability of service were prime considerations, that was installed in a California state institution for the insane.

Some Practical Details on

Changes In a Distribution System

Which Have Lowered Maintenance Costs, Cut Fire and Accident Hazards and Increased Reliability of Service

By B. R. FRITZ
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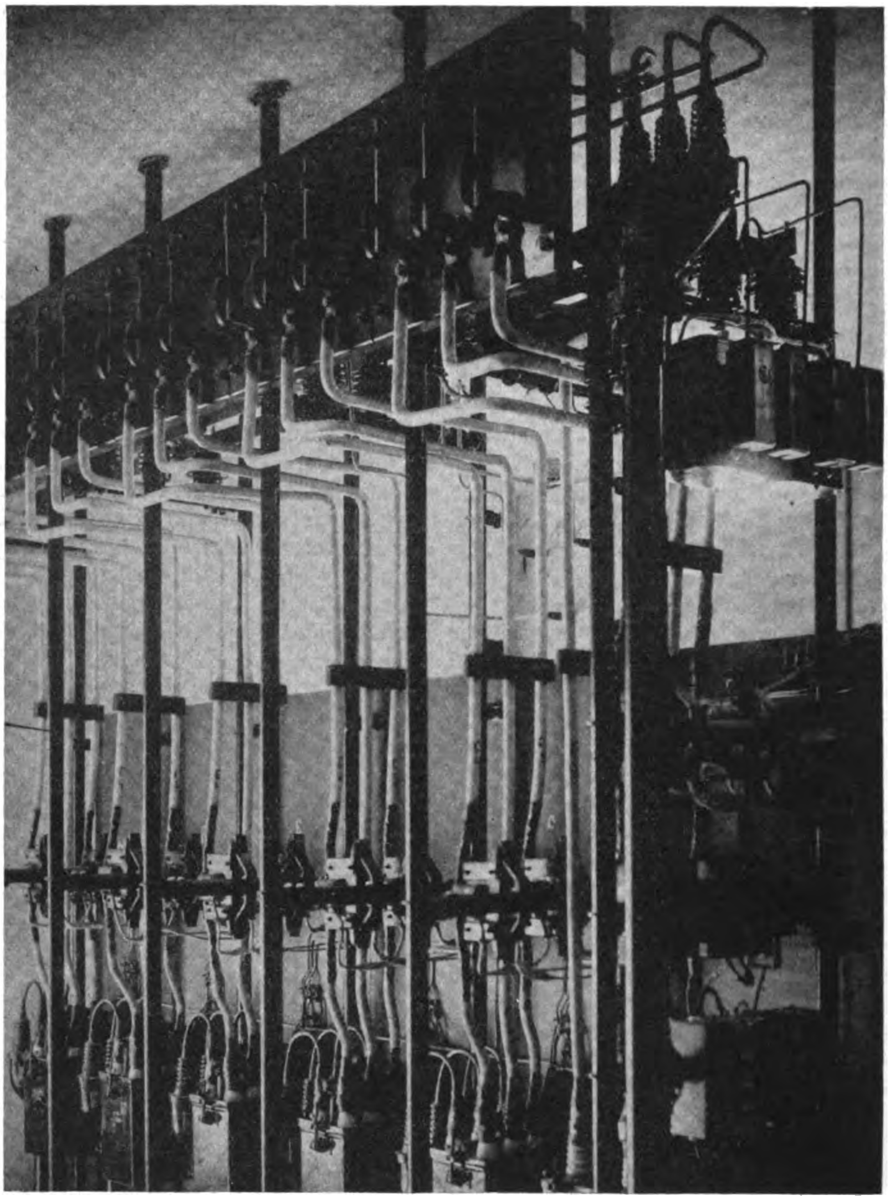


This shows the high-tension oil switches and disconnects, in the main substation, for the outgoing 2,400-volt lines.

RECENTLY I was called upon to do the field work in laying out and making recommendations for the installation of a distributing system for the Napa state hospital. This is the largest of six similar institutions for the care of the insane. At the present time there are about 3,000 inmates in the institution proper, which covers a great many acres of ground. Two large ranches are operated in connection with it and it is, on the whole, as nearly self-supporting as possible.

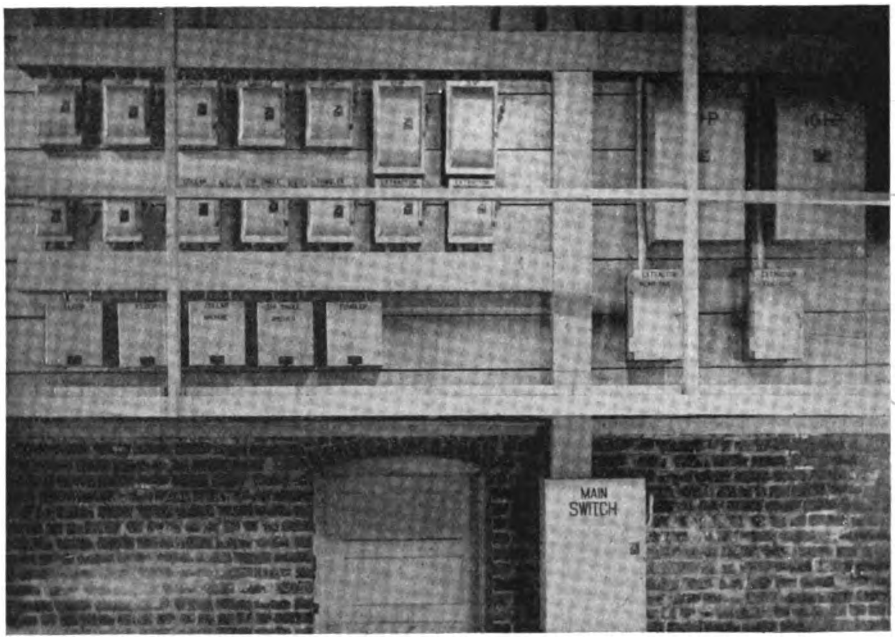
A thorough inspection of the existing installation showed that it had been outgrown and was inadequate for the demands placed on it. As the institution had grown, new circuits had been run from time to time to meet changing conditions. Much of this work was poorly done and as a result make-shift wiring was everywhere in evidence. It was not only a serious fire hazard, but was also dangerous from the standpoint of personal safety. As an example of the conditions, the main building was supplied by a power company with current at 2,400 volts. This was stepped down to 220 volts, three-phase, and 220 volts and 110 volts, single phase, at three different places in the basement. The power company had twenty-one meters to measure the current used and nearly a day was required to read all of these meters.

It was plainly evident that any attempt to revamp the existing installation would be very difficult and expensive. Recommendations were made, therefore, to abandon entirely the existing installation and put in a complete underground distribution system, as this would eliminate almost entirely the fire and personal injury hazards.

In the new installation, electrical energy is delivered at 2,400 volts, three phase, by the power company from its hydro-electric generating station in the Sierra-Nevada mountains over a main cable consisting of three No. 0 varnished-cambric cables. This cable terminates in the main sub-station, which is built of brick and concrete. The primary board shown in Fig. 1, is located in this substation and consists of one metering panel on which all of the energy used is measured both by the power company and by the institution, one panel with oil switch, voltmeter and voltmeter receptacle, and five panels with oil switches for the out-going, 2,400-volt feeders to

Fig. 2—The trough system of wiring was used for the switchboard which controls the motors in the laundry.

Push-button control is used for the motors in this department. This switchboard, which consists of the starters and enclosed line switches, was mounted 7 ft. above the floor. The main switch alone can be operated from the floor. The troughs for the wiring were made of No. 14 galvanized iron; the covers are made in sections and are fastened with machine screws.



the various distribution points. A recording watt-hour meter is installed on the meter panel for use in making rates. Also, above one of these out-going panels is located a ground detector of the electrostatic type. Some time ago a storm put the power company's ground detector out of service and for a short period all trouble on their lines was located from this station.

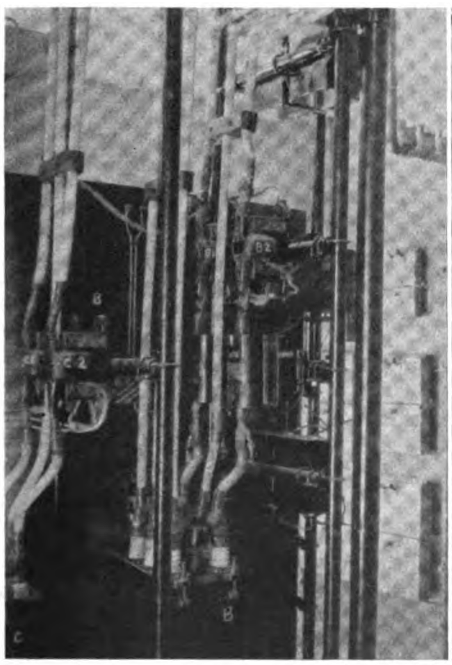
Behind the primary board is located the primary rack where all of the out-going primary lines are fed through the oil switches and disconnects which have 90-deg. stops and are used to isolate the oil circuit breakers and equipment so that they may be worked upon with absolute safety. These disconnects are mounted 8 ft. above the floor, as shown in the illustration at the beginning of this article. All of the primary lines leave the racks through a three-conductor pothead, leading to the primary pit, from which they go to the main manhole which is located in the center of the road in front of the substation.

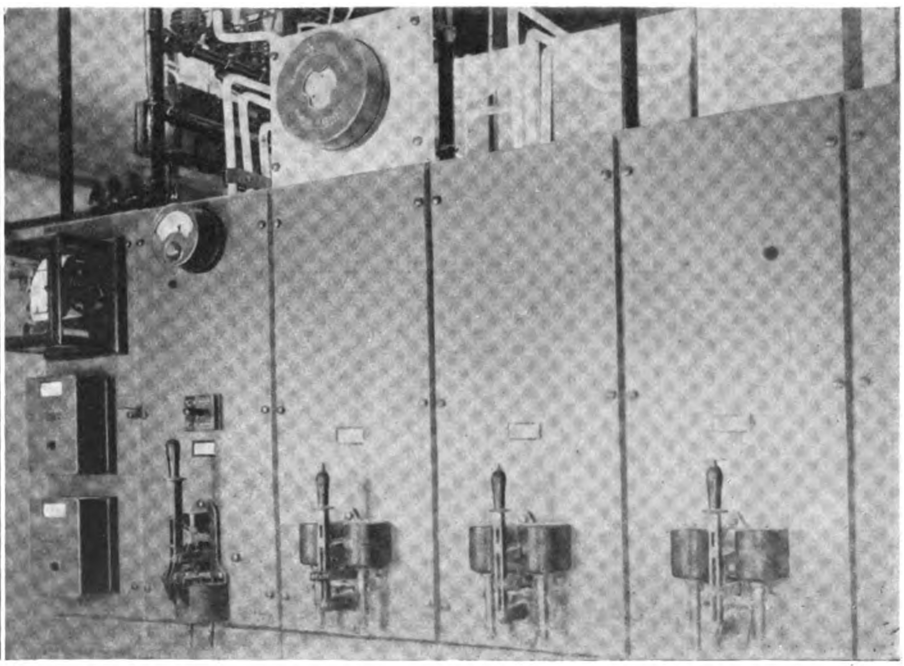
The secondary board is placed at a right angle to the primary board and is of the safety first type (see Fig. 4, *B*). This board also has a pit behind it where all of the low-voltage cables are brought in. This pit and the primary pit as well have covers made of ¼-in. steel plates, but are not inter-connected. The secondary board is fed from a closed-delta bank of transformers consisting of one 150-kva. and two 50-kva transformers. The lighting circuits in this vicinity are taken from one of these transformers. All of the cables behind the secondary board were taped and treated with water glass. The secondary buses from the transformers are made of 3/16-in. x 2-in. copper and, as will be seen from Fig. 4, *A*, are suspended 8 ft. above the floor on a pipe framework. This construction makes it easy to remove a transformer in case of a burnout. In front of the transformers is a pit which is connected with the sewer and is capable of holding all of the oil from one transformer.

This substation also feeds another substation which is located near the water-pumping plant, which has a connected load of 250 hp. This pumping plant substation, a view of which is shown in Fig. 4, *C*, has three, 75-kva., transformers which step the voltage down from 2,400 volts to 220 volts, three-phase. Inas-

Fig 1—High-tension switchboard in main substation.

The primary board, shown at the right, consists of a meter panel, a voltmeter and main oil switch panel, and five panels on which are mounted oil switches for the 2,400-volt lines going to the various buildings and departments. The electrostatic ground detector can be seen at the top of the third panel from the left. The small photograph at the left shows the rear of the meter panel.





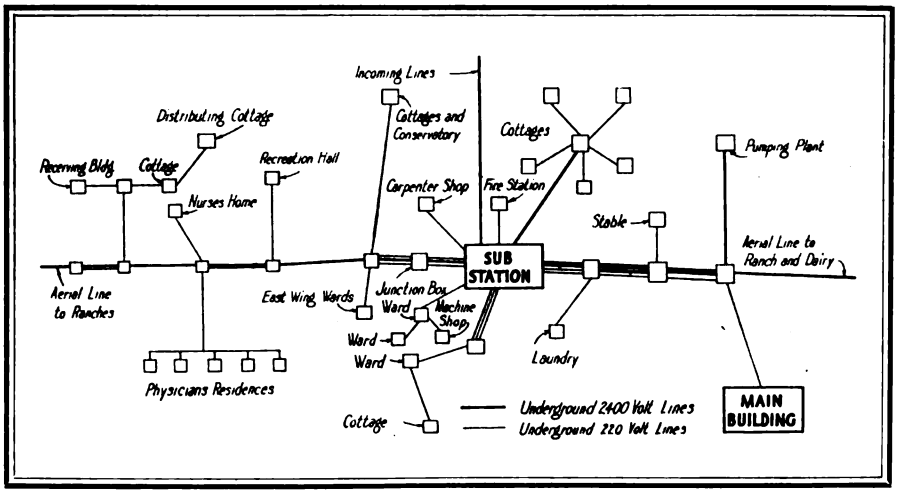


Fig. 3—Single-line diagram showing location of buildings and high- and low-tension feeders.

much as the low-voltage motors draw a heavy current, costly bus work was avoided by running two 500,000 circ. mil cables from each transformer to a pull can, located on the pump house wall back of the transformers, where the delta was closed. Besides the saving in cost, this construction gives a greater current-carrying capacity than if the delta had been closed directly at transformers and three 1,000,000 circ. mil cables run in.

The installation of the electrical equipment in the pumping plant was very carefully planned and carried out. There is no exposed wiring and every precaution was taken to insure maximum safety to the operator and reliability of operation. At this pumping plant the water is raised by air from wells which are 350 ft. deep. From the wells the water is discharged into a large concrete pit from which it is pumped under pressure into the water mains.

The laundry, which is another power-using department, is fed from the main substation through a 350,000 circ. mil 3-conductor cable with a weatherproof No. 00 neutral. Owing to the fact that some of the patients in the institution work in the laundry and in the bakery, special precautions had to be taken in locating the electrical equipment so as to make it as nearly fool-proof and free from the possibility of interference as can be. In fact, this condition was given prime consideration in the installation of all the equipment in the institution. For this reason, these two buildings were completely re-wired throughout.

The switchboard, Fig. 2, which contains Trumbull enclosed, externally-operated knife switches and the motor starters, was placed 7 ft. above the floor on a platform, with the main switch on the floor level. Nearly all of the motors are suspended from the ceiling, being bolted to steel I-beams. A few small motors, properly guarded, are mounted on or near the machines which they drive. All of the machines in the laundry are belt-driven. All motors have conduit terminals and are started and stopped by push buttons, so that in case of accident the foreman needs to step but a few feet to shut off all power. With the manually controlled starters previously used, the patients were continually blowing fuses and causing annoying delays.

The power factor of the laundry had previously been very low; so the writer put a recording watt-hour meter on all of the motors. As a result of these tests, one 25-hp. motor was replaced by a 15-hp. motor and smaller motors were put on several machines, making individual drives. (*Continued on page 403*)

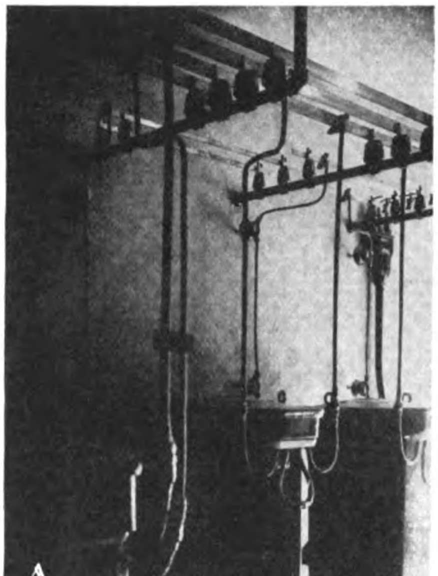
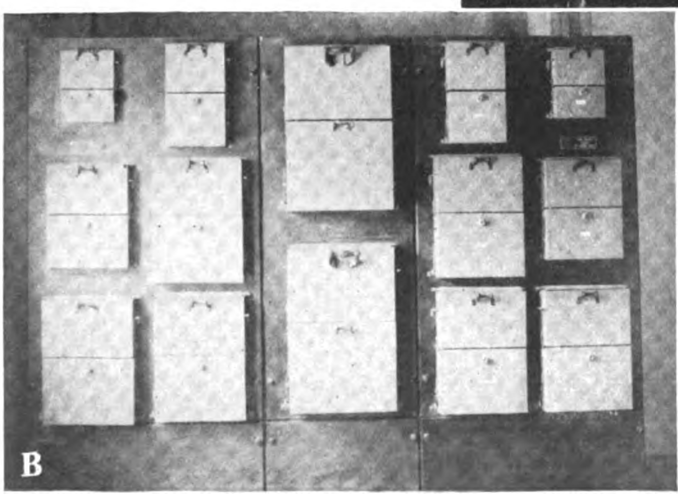

A

Fig. 4—Convenience and safety were considered first in this installation.

A. The secondary buses from the transformer bank feeding the low-tension lines through the secondary board in the main substation are carried on pipe framework 8 ft. above the floor, thus making it an easy matter to remove defective transformers. *B.* The low tension board is of the safety-first type. *C.* One end of the pumping plant substation, showing the bank of three 75-kva., 2,400-220-volt transformers. Costly bus work was avoided by running two 500,000 circ. mil cables from each transformer to a pull can back of the transformers and closing the delta there.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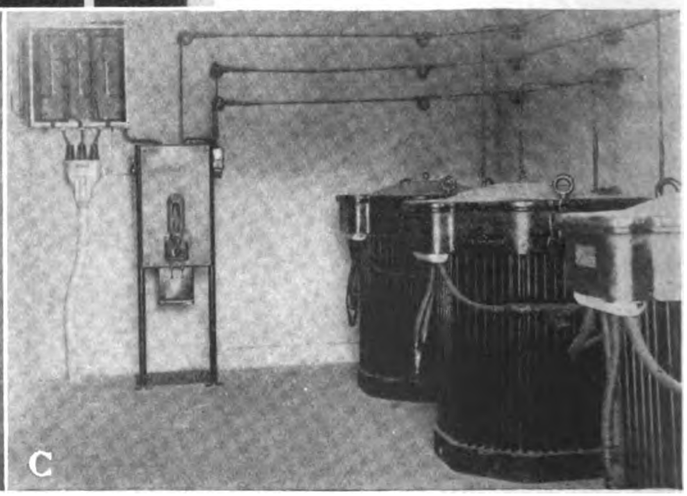
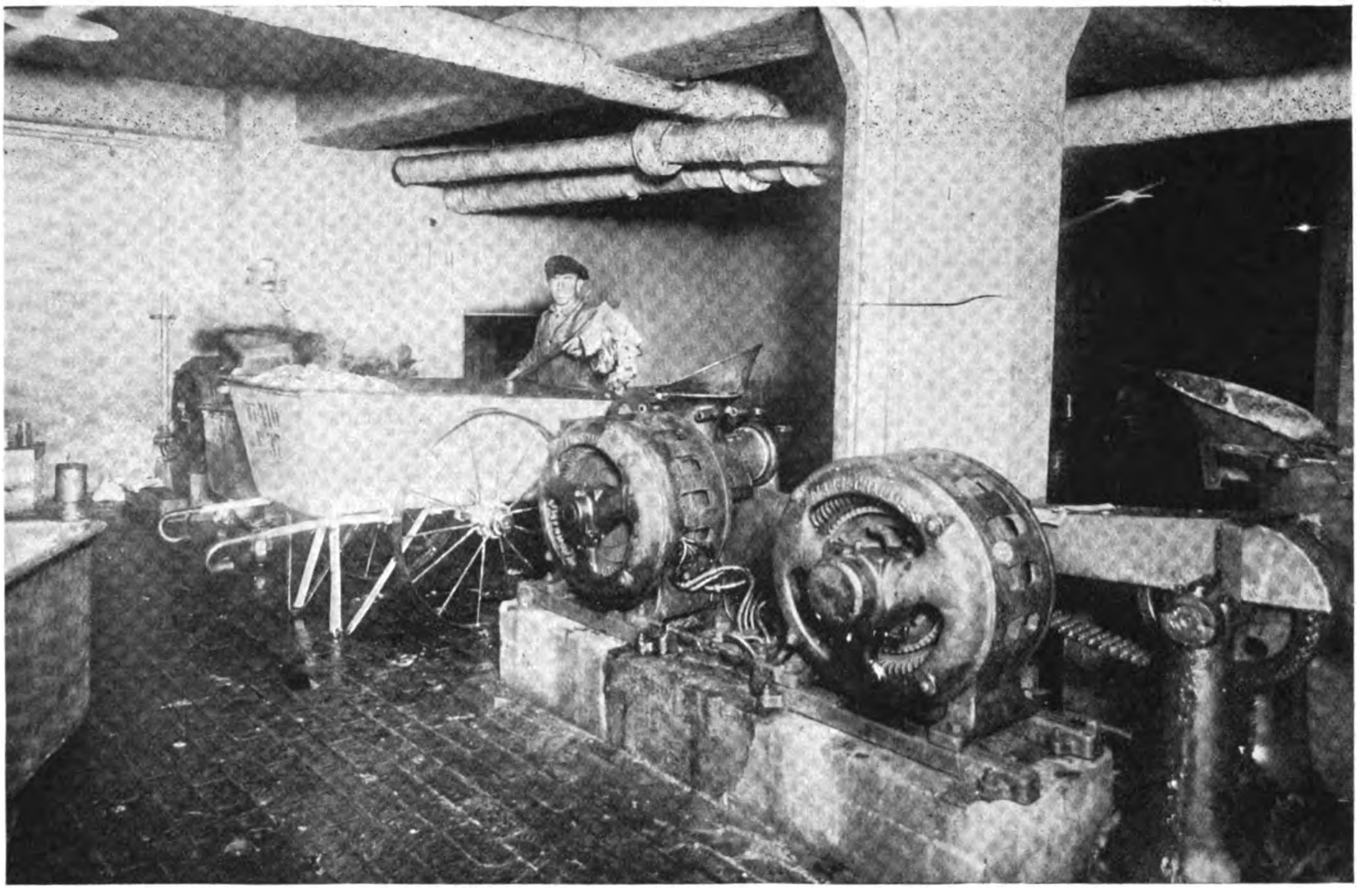

C



These motors operate meat grinders in a packing plant and are washed out, along with other apparatus, with boiling water at the nightly cleanup to remove grease accumulations. Under these conditions the average life of the insulation is about nine months.

Practical Details of

Insulating Varnish Tests That Are Easy to Make

In any Repair Shop and Indicate the Kind of Varnish Best Suited to Conditions Under Which Apparatus Must Operate

By H. L. HAZELTINE
Engineer of Insulation, The Sterling Varnish Co., Pittsburgh, Pa.

IN THE preceding articles the writer has taken up in a general way the characteristics of insulating varnishes and their solvents, the equipment for their application and some causes of troubles, with their remedies. The question that now most naturally arises is how to choose the varnish that is best suited to the conditions under which a particular piece of apparatus must operate. This is probably the most perplexing problem of all. There are so many of these insulating materials, which vary only slightly in composition and characteristics, that they tend to create confusion in the minds of the user. Yet each one is designed for a purpose.

Obviously the first step is to select the general type of varnish insulator that will be likely to give the best results. This may be done by making a careful study of the conditions to which the finished machine is to be exposed and the limitations of the shop equipment. The next step is to pick out the particular materials from this general class that will be productive of the best results.

As in other walks of life experience is the best teacher. It is, however, expensive to make production trials of many different varnishes, especially when some may be totally unsuited to the work and may be the cause of disastrous failures. Some other means of visualizing the characteristics of a varnish before purchasing in large quantities must be provided and for this reason tests on a small scale have been devised not so much to determine the actual suitability of a given product as to indicate those which are of sufficient interest to warrant a more extended trial.

Small shops are not usually equipped for making detailed scientific tests and hence they are inclined to leave the choice of a material to the personal opinion of the shop foreman or engineer rather than to a definite knowledge of the product itself. Tests of as elaborate or of as simple a nature as desired may be devised, but it is a general axiom that in most cases the action of any material under forced conditions is not the same as under normal conditions. Hence, when tests are used, as they should be, to indicate a product having characteristics that ap-

pear to be suitable and whose results are to be backed by actual production trials, the simple easy-to-make ones will be found to give satisfactory results.

Those outlined below have been designed with these ideas in mind. They require no special apparatus and, therefore, are particularly adapted to the needs of small shops. They are of necessity designed for general conditions, but it is hoped that they will suggest other and equally simple tests that may be made when special occasions arise.

Tests That Can Be Made In Any Repair Shop

Specific Gravity—Uniform specific gravity in a varnish is one of the most important requirements. It gives the user quick and definite information as to the uniformity of the product purchased and protects him against any change that might be contemplated in its manufacture. It also serves as a means of maintaining a varnish at a proper consistency.

An ordinary hydrometer graduated for liquids lighter than water (with readings less than 1.000) is all the apparatus required and should be a part of every shop equipment. When corrections for temperature variations are applied the readings are sufficiently accurate for any ordinary work.

The specific gravity of a varnish unfortunately varies not only with the percentage of base or useful material, but also with the nature of the solvent or base used and hence its measure is quite valueless when two different varnishes are to be compared. For example, a material having a solvent with a specific gravity of 0.720 and 50 per cent base would probably have a gravity of about 0.860, whereas one made up of the same solvent and 40 per cent base would have a gravity of only 0.832, but if the second material had a solvent with specific gravity equal to 0.790 its gravity would be 0.874. It will be seen, therefore, that contrary to rather general opinion the specific gravity is not a measure of the "body" of a varnish and should be used not as a means of comparison but as a means of maintaining the consistency of a particu'ar product.

Viscosity—The actual viscosity of a varnish is the measure of its rate of flow as compared to that of distilled water. Like specific gravity its value varies with the type of solvent used and the percentage of base; hence its determination has no significance in comparing the qualities of two different products. Furthermore, it does not indicate the way in which a material will flow from coils or other types of work. It is, therefore, not a quality of any particular interest and the small shop is hardly justified in purchasing the rather expensive viscosimeter required for measuring this quality.

IN THIS ARTICLE, which is the last of a series on insulating varnishes, Mr. Hazeltine describes some simple tests and gives the interpretation of results that make it possible to check up on varnishes that are being used for different insulating requirements and to select the type of varnish best suited to the conditions to which the apparatus is likely to be subjected.

The first article in this series appeared in the March issue and dealt with varnishes and their solvents. The second, in the April issue, took up methods of applying varnishes. The third, in the June issue, discussed the best ways to use varnish for protecting windings against moisture, oil and metallic dust. The fifth article, in the July issue, outlined common insulation troubles and explained the ways to overcome them.

When an article is dipped in varnish the varnish tends to run off thin at the top and to accumulate in a thicker coat at the bottom. The difference in thickness of film is known as the *slip* or *working viscosity*. It is evident that material having the *least slip* will drain more evenly from articles dipped in it and will deposit a more uniform coat than one having a *greater slip*. It will be seen, therefore, that unlike the actual viscosity, the *working viscosity* has a very interesting value to the user.

The *slip* in 10-in. or the difference in thickness of film taken at points 10 in. apart has been adopted as the unit of measure of *working viscosity*. It may easily be measured as follows:

Take a strip of a good quality of bond paper about 0.0028 in. thick, 4 in. wide by 18 in. long. With a lead pencil draw a line across the paper ½ in. from the bottom for a trimming line. Then 3 in. above this line draw another and mark it 12-in. line. Five inches above this draw another and mark it 7-in. line; five inches above this line draw another and mark it 2-in. line. Two inches above this draw still another line and call it dipping line. Dip a sheet to the dipping line in a deep vessel containing the varnish to be tested and withdraw at a slow, uniform rate of speed, taking care that there are no air bubbles on the surface of the varnish to adhere to the paper. It is absolutely essential that the rate of withdrawal shall be uniform otherwise an uneven film will result. After a little practice, however, good test papers can be made quite rapidly. Dry thoroughly either by baking or air drying according to the nature of the varnish used; then with a micrometer measure the thickness at the 2-in. line and at the 12-in. line. The difference is the *slip* in 10 in. A measurement of the thickness at the 7-in. line serves as a check on the result as the difference between this and the thickness at either the 2-in. or 12-in. line should be one-half the value obtained.

Dielectric Strength—These same test sheets may also be used for determining the disruptive strength of the varnish. Too much importance has been placed upon this test in the past at the expense of other more vital characteristics. Many small shops feel that because they do not have the expensive special testing sets required, they cannot judge the qualities of insulating varnishes and hence are inclined to abandon all tests on this account. It would be well to call the attention of such shops to the fact that many of the larger factories have abandoned this test altogether because of the difficulty of obtaining reliable results. Hence, it would be quite safe for the smaller shops to follow their example. The results obtained even when the test is most carefully made on highly specialized apparatus and on test specimens prepared with the utmost care do not justify the installation of the high-voltage transformer required, when such is lacking. A variation of as much as 100 per cent has been noted in the disruptive strength taken at different points on the same specimen. It would appear therefore that no varnish should be rejected for showing a low value alone. All insulating varnishes manufactured by reliable firms that understand the requirements have a dielectric strength greatly in excess of any that the user may put upon it. What difference does it make whether a material has a disruptive strength of 2,000 volts per mil or only 800 volts per mil when at least fourteen mils of insulation will be

used and the impressed voltage will not exceed 400 or 500 volts?

Flexibility or Heat Endurance—The same test sheets already described may be used in determining the degree of resistance to continued heat possessed by a given varnish. In preparing the test specimens care should be taken that the films are as near the same thickness as possible. Otherwise the heavier coat is liable to crack too soon due to the fact that the surface becomes hard and does not possess sufficient elasticity to prevent the soft material from bursting the outside skin.

After thorough drying the sheets are placed in the oven and baked at a uniform temperature of from 100 deg. C. to 105 deg. C. until the varnish cracks when the paper is creased. The time required before cracking occurs is a measure of the resistance to heat.

Oil and Water Resistance—A rough idea of the resistance of the film to the effects of oil may be obtained by rubbing the surface of one of these test sheets with a piece of waste that has been soaked in transformer or machine oil. Care must be taken that the pressure applied be as nearly as possible the same on each paper when comparisons are to be made. Care should also be taken that the varnishes are thoroughly dry and that they have all been baked at the same temperature.

Where more definite information is needed both oil and water resistance may be measured at the same time in this way: Take several pieces of perfectly clean copper ribbon about 2 in. wide by 5 in. long. Dip them in the varnish for about 4 in. of their length; then hang them in the drying oven and bake until thoroughly dry. Be sure that the varnish is dry. Then trim off about ½ in. of the bottom of the strip with a pair of scissors, as capillary attraction practically removes the varnish from the edges of a strip of copper. As the varnish and copper together have been cut at the bottom and the varnish does not extend up the whole length of the strip, it is apparent that we have two sheets of the varnish to be tested laid on one sheet of copper.

Next take a glass beaker or other suitable container deep enough to allow the immersion of the copper strips for about 3 in. of their length and fill the vessel 4 in. deep with water and ½ in. with any good quality of lubricating oil. Hang the test pieces in the liquid. This may be done by punching a hole through them and sticking a glass rod through. The rod may be laid across the top of the vessel so that it rests upon the edges. Care should be taken to see that the coppers do not come in contact with one another or within ½ in. of the bottom of the vessel. Then apply heat to the bottom of the container with a gas jet until it boils and continue the boiling until the varnish films are affected. This may be judged by removing the strips from time to time and testing with the finger nail.

It must be remembered in making oil resistance tests that transformer oil will have a greater effect than lubricating oil, hence it would be wise to use that oil to which the varnish will be subjected in practice.

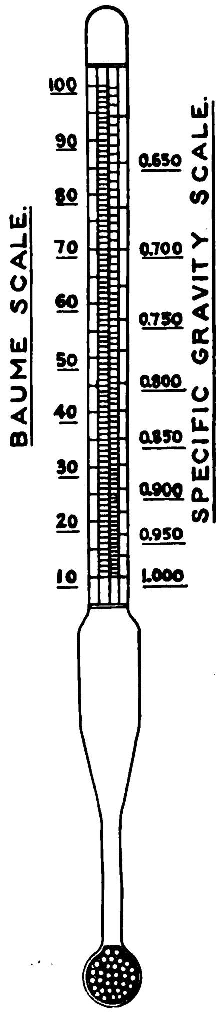
Acid and Alkali Resistance—Take a piece of close-grained wood about 4 in. wide and 5 in. or 6 in. long. Be sure that the surfaces are smooth. Treat it with varnish so that a good, continuous coat is formed. Place a drop of weak acid or alkali at several different points on the surface. Of course the water in these drops will evaporate and hence we will obtain the effect of acids and alkali at varying strengths. From time to time renew these drops until it is seen that the drop has broken through the surface of the varnish. A comparison of the times required will indicate the acid resistance of the different materials.

Penetration — Good penetrating qualities are of the utmost importance, as a varnish must be capable of passing through fibrous insulation and providing the protection needed

Hydrometer suitable for testing specific gravity of insulating varnishes, with Baume and specific gravity scales.

COMPARISON OF BAUME AND SPECIFIC GRAVITY SCALES.

For Liquids Lighter than Water at 15° C. (60° F.).



Baumé	Specific Gravity	Baumé	Specific Gravity	Baumé	Specific Gravity
80	0.667	56	0.753	32	0.864
79	0.670	55	0.757	31	0.870
78	0.673	54	0.761	30	0.875
77	0.676	53	0.765	29	0.881
76	0.680	52	0.769	28	0.886
75	0.683	51	0.774	27	0.892
74	0.686	50	0.778	26	0.897
73	0.690	49	0.782	25	0.903
72	0.693	48	0.787	24	0.909
71	0.697	47	0.791	23	0.915
70	0.700	46	0.796	22	0.921
69	0.704	45	0.800	21	0.927
68	0.707	44	0.805	20	0.933
67	0.711	43	0.809	19	0.940
66	0.714	42	0.814	18	0.946
65	0.718	41	0.819	17	0.952
64	0.722	40	0.824	16	0.959
63	0.725	39	0.828	15	0.966
62	0.729	38	0.833	14	0.972
61	0.733	37	0.838	13	0.979
60	0.737	36	0.843	12	0.986
59	0.741	35	0.849	11	0.993
58	0.745	34	0.854	10	1.000
57	0.749	33	0.859		

To convert degrees Baumé to Specific Gravity:

$$\text{Sp. Gr.} = \frac{140}{130 + {}^\circ B}$$

To convert Specific Gravity to degrees Baumé:

$$^\circ B = \frac{140}{\text{Sp. Gr.}} - 130$$

Above scales are at the standard reference temperature 15° C. (60° F.), on which commercial ratings are based.
To find specific gravity at other temperatures;
Add 1° B. for every 5° C. (9° F.) below 15° C. (60° F.).
Subtract 1° B. for every 5° C. (9° F.) above 15° C. (60° F.).

in the interior of the windings. A rough determination may be made by taking a bar of metal or wood 1 in. square and 12 in. long. About this wrap many layers of the same cotton tape used in the shop, being careful that the lap is one-half the width of the tape on each test piece. In order to reduce the number of layers required, a layer of thin paper may be substituted for every fifth layer of tape, taking care that the paper passes once around the bar and that the edges come together without overlapping. Dip the bars in the varnishes to be tested allowing them to remain for exactly the same length of time; remove and dry thoroughly. Then with a sharp knife cut through the tape and paper and count the number of layers through which any traces of varnish can be found.

Shop Test—This experiment will show you the relative amount of care that must be taken in maintaining a given varnish; that is, whether the care to keep the base from going out of solution is excessive. The only apparatus required is a small container and a hydrometer. Fill the container with varnish of known specific gravity and allow it to stand with the top open so that the solvent will evaporate by action of the air and heat in the shop. Each morning measure the specific gravity and add sufficient solvent to bring the varnish back to the original consistency. A good varnish should stand this repeated thinning without livering or going out of solution for at least thirty days. In most shops the material stands in a tank for a considerably longer period. Of course, when the tank is covered, as it should be when not in use, not nearly so much thinning is required. Hence this test is considerably more severe than ordinary shop conditions would seem to require. Nevertheless it will give very definite information as to whether the care required of the material is so excessive as to make the cost of handling prohibitive.

Percent of Base or Useful Material—The most important test that can be made on a varnish is the determination of the percentage of base. It is not fair either to yourself or to those manufacturers of varnish who are supplying a minimum of solvent to purchase materials on a price per gallon basis. You are buying protection, not thinner whose only value is to provide flowing qualities and which passes off into the air once the varnish has been applied. You can usually purchase thinner nearly as cheaply as the varnish manufacturer and as you must thin anyway, you save yourself considerable in freight charges.

The importance of such a test is clearly shown by this episode. A company which had been buying a certain grade of varnish for a number of years decided to make a change because it would save them 6 cents a gallon on the purchase price. This material had been guaranteed as the equal electrically and in gravity to that which had been previously used. Nothing was said about it being equal physically. After six months' trial it was found that exactly twice as much of the new material had been used as was formerly the case with the old. An examination of the new product showed that it contained three quarts of solvent to every gallon of varnish, whereas the old contained only two quarts. The gravity was maintained equal by the use of a heavy solvent. Although the price per gallon of varnish was 6 cents less, the new material was more expensive to use and the ratio of the actual value was one to two because twice as much of the new material had to be used for a given amount of protection.

A rough estimate of this percentage of base may be made during the preparation of the test sheets described under *Viscosity*. If the varnish is weighed before the sheets are dipped and the dried film be weighed after the drying, with proper allowance for the weight of the paper, it may readily be seen that a very rough estimate may be made.

Again, if the specific gravity of the solvent used in the varnish is known the percentage of base may be determined by calculation from these same test sheets.

A more accurate determination may be made by the use of the ordinary distilling apparatus shown on page 156 of the March, 1924, issue of INDUSTRIAL ENGINEER for

Method of testing the resistance of varnish films to hot oil and water.

THE STERLING VARNISH COMPANY ENGINEERING DEPT.

PITTSBURGH, PENNA. U.S.A.

MATERIAL TEST SPECIFICATION No 2.

QUICK DETERMINATION OF THE RESISTANCE OF DRIED VARNISH FILMS TO HOT OIL AND WATER.

GENERAL.

This test is designed to determine quickly the resistance of a dried varnish film to boiling water and oil, and to give a method of comparison of results obtained. It is evident that a film which will withstand for a short time the strenuous trial given below is more calculated to meet ordinary service conditions than one which will be sooner effected by the test. It has been proved by long time-tests that such is really the case.

PRECAUTIONS.

Be sure that the varnish film is thoroughly dried right through. In order to have a definite and equal fashion of procedure, it is suggested that the test be made upon a film baked twice as long as the baking instructions given in directions for using the varnish in question.

APPARATUS.

A litre glass beaker 3½" in diameter and about 7½" high. Laboratory devices for holding as shown in sketch. A sand bath 6" in diameter filled with clean sand to a depth of ½". A standard bunsen burner.

SAMPLES.

Prepare samples of bright clean copper ribbon 5 mils thick, 2" wide and 5" long. Dip them in varnish to be tested for a distance of 3½". Allow to drain and then bake at a temperature and for a time twice as long as indicated on direction label for using varnish in general practice.

TEST.

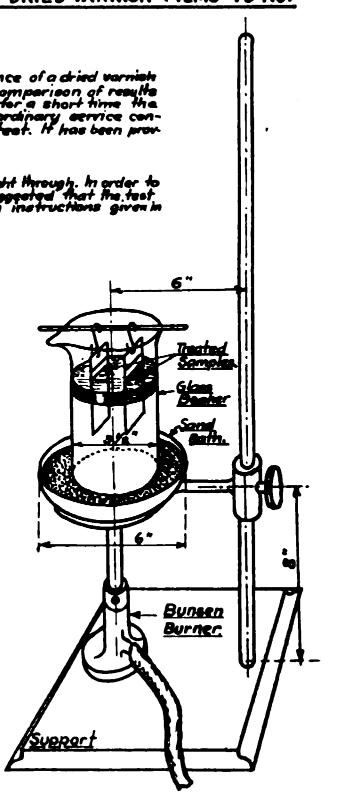
Assemble apparatus as shown in sketch. Fill beaker 4" deep with water and then pour carefully on top ½" of light machine oil. Hang treated samples in the liquids so that top of varnish film is ½" above surface of the oil and then bring to a hard boil with flame about 3" long. The water and oil should boil fiercely and times should be calculated from the moment the boiling commences. Take samples from oil every half hour and test with fingernail. Note time taken before varnish becomes soft, and until it is visibly effected and shows blistering and loosening of film. Consider the index number as the mean time in minutes of the two determinations made above.

REMARKS.

A good oil proof varnish will not be softened by the above test after 2 hours boiling and will show no visible effects after 4 hours boiling.

It is suggested that no varnish be considered as meeting a specification requiring oil proofness except when the index number found above is equal to or greater than 180. Those between 100 and 180 may be designated as fairly oil proof and those below 100 should make no claims in this direction.

It is of course understood that the results of future work may change the above figures, and it is hoped that any observations tending to establish their accuracy or the reverse will be sent to this department, so that this specification may be changed and brought up to date.



determining the qualities of the thinner used. Considerable skill is, however, required in making this test and hence it is suited chiefly to those factories having an expert chemist.

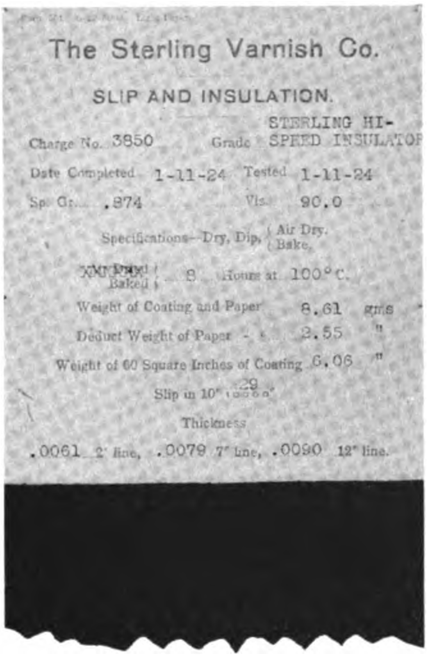
The tests outlined above are at the best exceedingly rough and the ideas as to the comparative merits of two different materials can only be estimated. Space will not permit a description of the more scientific tests requiring extensive laboratory equipment. These have been very ably described in the *Tentative Standards for Testing Insulating Varnishes* compiled by the American Society for Testing Materials. Those interested in the subject may obtain copies from the Secretary of that Society at Philadelphia, Pa.

Results of Tests Must Be Properly Interpreted

Tests, whether of the scientific kind or of the rough shop kind, have no value to the user of varnish unless the results are interpreted and brought to a common basis. It is quite true that some varnishes are worth more money than others due to their having stood the tests better, or to their having a higher percentage of base, or because the price per gallon is less. Stating this in mathematical terms, the value of a varnish varies directly with the test results, directly with the percentage of base and inversely as the price per gallon.

That is, we could write an equation in which the value of the varnish equals (test results × percentage base) ÷ (price per gallon).

The percentage of base and the price per gallon are both expressed in figures. If then the test results could be reduced to a number, we could express the value of a varnish



Sample of a test for slip or working viscosity of a varnish.

Details for making this test are given under the heading *Viscosity* on page 382. It helps to pick out a varnish that will drain evenly and provide a uniform coat when articles are dipped in it.

by a number and the greater this number the greater the value of the material.

It is quite possible before starting tests to determine a set of ideal values which represent approximately our idea of the relative importance of the qualities one to another and to the whole, or 100.

Suppose that we were testing varnish for the treatment of apparatus which will be subjected to considerable heat and to strong acid fumes. The qualities that most interest us are: flexibility or life at 105 deg. C.; elasticity or resistance to the expansion and contraction of the metal used in the machine under service conditions; acid resistance and comparative dielectric strength.

Dielectric strength being of the least importance could be given a numerical value of say 10; life, acid resistance and elasticity being of equal importance could be given an arbitrary value of 30 each. We could then tabulate our values as shown in the table below.

The values for the samples are determined in this way: Suppose the values for the dielectric strength in volts per mil for each of the four samples are: No. 1—1,600; No. 2—960; No. 3—1,280; No. 4—640. If 1,600 volts are taken as the ideal value, or 10, 960 is 3/5 of 1,600 or 6, and so on.

The relative value is determined by multiplying the percentage of base by the test totals and dividing by the cost per gallon in cents. It will be seen that sample No. 1 is the relatively best purchase because its relative value is the highest.

Without this interpretation, the choice of the engineers would probably be No. 4, although the small percentage of base and the high cost per gallon do not warrant its adoption. Sample No. 3, on the other hand, would be the purchasing agent's choice, as its price is the lowest. Sample No. 1 is the better purchase on the basis of percentage of base alone in the ratio of 50 to 40. That is, to be an equal purchase on a price basis No. 3 should sell for 4/5 as much as No. 1, or 88 cents per gallon.

By this method it will be seen that the personal element has been eliminated from every feature having to do with the selection of varnishes, except the detail tests. The design of these tests should be such as to eliminate this feature as much as possible also.

It will be noted that in the list of qualities under *Tests That Are Easy to Make*, the elasticity has been mentioned, although no test for it has been described. Elasticity may be defined as that quality of a varnish which enables it to resist the strains put upon it by the expansion and contraction of the metal, during operation, in the machines to which it is applied. It is probably dependent upon the amount of drying oil contained in a particular material, the nature of the drying oil and the way in which this drying oil has been treated in manufacture. The quality may best be determined by a comparison of the way in which the machine *(Continued on page 402)*

Comparative Data From Tests on Four Samples of Insulating Varnish

Property	Ideal Values	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4
Dielectric strength	10	10	6	8	4
Elasticity	30	25	22	10	24
Life at 105 deg. C.	30	20	15	17	26
Acid resistance	30	25	20	16	28
Totals	100	80	63	51	82
Percentage of base	....	50	45	40	42
Price in cents per gal	....	110	108	96	130
Relative value	....	36	26	23	26

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT F. E GOODING A. J. WHITCOMB

Chicago, August, 1924

A Suggestion About Plant Housekeeping

PLANT MEN may take a tip from the good housewife who, during her annual spring and fall housecleaning, turns everything over, moves it around and gives it a thorough going over even though she sweeps and dusts several times a week throughout the year.

Some plants approach this weekly clean-up by shutting down machines from a quarter- to a half-hour earlier on Saturday and have each man wipe off his machine and tidy up the space he occupies around it. Even with this, however, an annual clean-up is worth while as many things accumulate during the year which really belong elsewhere. With some industries the summer is a slack time which offers an excellent opportunity to make a real housecleaning job of the clean-up. Then everything movable can be shifted and cleaned under and around, accumulations disposed of and paint brush applied here and there where necessary. Lamps, lampshades, windows and skylights, generally need more frequent attention but if they haven't received it here is a good opportunity to give them a thorough cleaning.

The Hows and Whys of Equipment Failures

IN A conversation last month with the superintendent of a large paper mill he referred to the difficulties of making repairs and changes on equipment when little thought has been paid to standardization and various types and makes of apparatus have been installed, with price largely governing the selection. In such a case a piece of apparatus is installed to try it out; then another that seems to have some better points but is no more expensive, until a switchboard or control section has a variety of devices for which repair parts must be carried or considerable expensive apparatus junked to start in on any plan of standardization that will be at all comprehensive.

Right here is a real problem. When someone before you has installed the miscellaneous apparatus and it's your job to make it operate, the suggestion to tear out the old and install new equipment is one which the management usually frowns upon and considers a little tainted with prejudice. So the usual plan is to get along with the old as best you can and replace it with such equipment as can be standardized upon as the opportunity comes up.

The tendency is to hold on to the best that has been used and gradually add the most modern of the same type and make. Here, the operating man has an opportunity for doing a manufacturer a good turn that is usually appreciated. He can make a report on failures of the apparatus, indicating their causes and point out those due to the equipment itself and those due to incorrect use or abuse. Such reports are usually worth money to the manufacturer because it is impossible for him to duplicate all the various pranks of actual service on his test floor and it is mainly through the experiences of operators and troubles that develop from service that the best form of design is evolved.

As this particular superintendent pointed out, it is a better plan for an operator to help perfect equipment by suggestions offered to the manufacturers, than to shop around to find something that is just right when he gets it but that adds type and different design complications to the equipment layout unless the entire plant can be rebuilt and new equipment installed. Even then the man who keeps records of the hows and whys of failures is the one who usually knows how to avoid them in the new layout.

Economy In One Direction May Be Waste In Another

AN OFFICIAL of a company that specializes in the repair of motors and certain industrial material-handling equipment recently said: "If plant owners would see to it that their equipment is properly taken care of, we would not have much to do. Ninety per cent of the failures in the equipment we handle are due simply to lack of proper attention."

The fact that maintenance is much cheaper in the long run than neglect and consequent repairs, has still to be learned by some factory managements and owners. It is an expensive lesson, but when it has once been learned it is never forgotten. The production losses entailed by the failure of an important piece of equipment and the cost of a rewind job, say, will ordinarily buy a good deal of maintenance.

A certain amount of repair work is necessary and inevitable. Bearings will wear out in time; equipment will be abused or receive injury in one way or another; and parts will occasionally break under the stresses imposed by unusual service conditions. Nevertheless, the amount of repair work caused by these mishaps is, in many plants, very small when compared to the amount of repairs that are caused by improper application, operation and care of the equipment.

The issue is simple: There is no escape from the fact that it costs money to operate and use equipment. The only question is whether this money shall be spent for properly-directed maintenance, or whether a greater sum shall be spent for repairs which are occasioned by the lack of attention. In the first instance the amount to be spent can be closely estimated and controlled; in the other it is a very uncertain quantity, and "the sky is the limit," as the saying goes.

Make a Graphic Picture of Your Plant Load

A POWER SURVEY of the plant load, made at regular intervals, is one of the best forms of insurance against power distribution failures that the plant engineer could ask for. An underground-cable failure that recently occurred in the coke plant of a large steel mill, is a case in point. Increased power demand and the addition of a few motors increased the load on this cable to the point where a disastrous burnout occurred half-way between two manholes. Since coke-making is, of necessity, a continuous process, the production loss and scrapped product caused by the loss of power from this cable can be readily imagined. An investigation undertaken *after* the failure had been repaired showed that not only was the cable overloaded but it was located in the vicinity of some steam pipes which, through the heat radiating from them, reduced the carrying capacity of the cable.

A power survey, similar to the one which Mr. Stafford describes in his article beginning on page 360, would have gone far towards eliminating a failure such as the one mentioned. A power survey of the load of the entire plant gives a mass of data that is hard to visualize; if the survey is made at yearly intervals, it is difficult to compare the results of each survey. Mr. Stafford in his article gives a line diagram which shows the location, size and connected load of each circuit, and also gives a chart which shows the comparative value of the departmental loads together with the power factor and the power and wattless components of each department or circuit. By means of these two diagrams the factors of the distribution system can be readily visualized and compared.

A power survey repeated at regular intervals and charted and analyzed as described will lead to conclusions that will save many a midnight cable repair job.

If You Are Sure It Can't Be Done You'll Never Do It

IT is usually easier to say that a thing can not be done, than to go ahead and do it. Perhaps this is one explanation of the interesting fact that many of the outstanding developments and inventions have been made by men whose training and experience were confined to other fields than the one in which they attained prominence.

For example, Pasteur, who discovered the antitoxin used in the treatment of hydrophobia, was not a physician. Bell, the inventor of the telephone, was a teacher of the deaf—not an electrician. Morse, the inventor of the telegraph, was a portrait painter. Ingersoll, who made the dollar watch famous, was a farmer, not a jeweler or watchmaker. Columbus, the discoverer of America was a comber of wool, not a sailor. The Wright brothers, who conquered the air with their flying machines, were originally bicycle repair men, not scientists.

This list might be extended to considerable length, but it is long enough to illustrate the point. Wide or increasing knowledge of a certain field often seems to bring with it merely a wide variety of reasons why certain things can not be done. In fact, the discoverer of insulin, by far the most valuable curative agent for diabetes, has been quoted as saying, in effect, that when he started work on this problem he did not take the trouble to become thoroughly familiar with all of the theories which have been put forth, or the work which had been done previously; if he had done so he would probably not have made his brilliant discovery. In other words he would have known too many reasons why diabetes could not be cured.

There are many other instances where scientists and inventors have united in declaring that certain things could not be done; and then somebody who had not heard of this verdict, went ahead and did them, because he did not know that they could not be done.

Almost anyone can give a dozen good reasons why certain desired results can not be obtained—but the world liberally rewards the man who can give even one reason why they can be obtained, and then proves it.

Don't Always Blame the Brushes

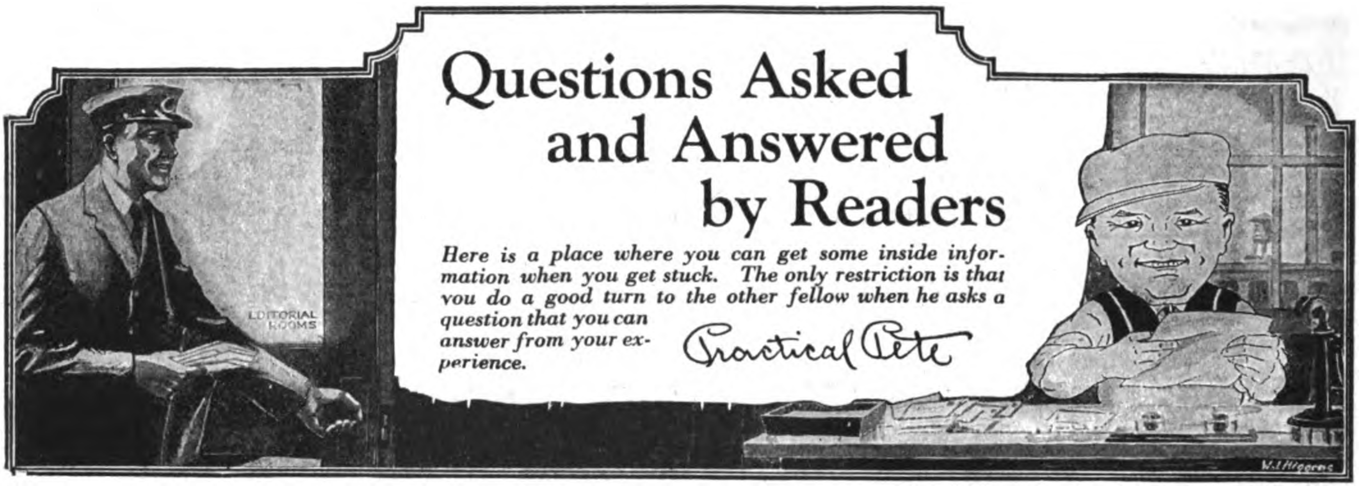
POOR commutation can be caused by a great variety of things. Too often in a case of commutation trouble, the superintendent is unduly influenced by the operator's report that the brushes are at fault, with the result that a competitive brush manufacturer is called in to prescribe new brushes.

This calls to mind the case of a generator furnishing the direct-current supply to a 5,000-hp. reversing motor driving the rolls of a billet mill in a steel plant. The duty required of this machine is exceptionally severe; hence any slight trouble experienced with the commutation of the machine rapidly becomes worse until destructive sparking takes place. This machine was operated for several years without more than ordinary trouble. Finally, however, commutation trouble set in. It soon got to the point where the commutator would flash over and a shut-down and repair work would be required. The electrical superintendent decided that the brush manufacturer was not making brushes as good as formerly and bought a new grade of brushes from a competitive manufacturer. The new brushes, however, did not function better than the original ones. Five more grades from several other manufacturers were tried with indifferent results.

Things were going from bad to worse and as a last resort a brush engineer from the manufacturer of the original brushes was called in. He diagnosed the case as commutator trouble and not brush trouble. He directly supervised the job of undercutting the mica and grinding the commutator and the job was done in a much more painstaking manner than was customary at that plant. The brushes were seated accurately. The spacing of the brush arms was found to be slightly off; so this was corrected. Needless to say no more brush or commutator trouble has been experienced with that machine.

Another case is recalled of a commutator on a motor-generator set in which four grades of brushes were tried before it was discovered that the commutator was not thoroughly seasoned and hence after being carefully ground, the bars would shift slightly—just enough to cause poor commutation. Obviously the trouble could be permanently corrected by seasoning and regrinding the commutator.

Instances like these show the time and money-saving value of suspecting other things besides the brushes when troubles show up at the commutator.



Who Can Answer These?

How Does Change in Speed of Motor Affect Horsepower?—I shall appreciate it if some reader of INDUSTRIAL ENGINEER can answer the following question: We have a 3-hp., 3,600-r.p.m. motor which we are changing to operate at 1,800 r.p.m. I should like to know what the approximate horsepower of the motor will be after this change, if we use the same number of turns of the same size wire in the stator.

Enid, Okla. C. E. S.

* * * *

How Should This Machine Be Placed?—It is common practice to place a pulley at right angles to a lineshaft which, of course, means that the belt has no twist in it. However, we have a 125-ton press and would like to place it in such a position that the pulley on this press will be 45 deg. from the lineshaft. I should like to know, (1) if this is an unusual way of running a belt, and (2) how should the machine be placed with the pulley in this position, so that the belt will not be continually slipping off.

Philadelphia, Pa. A. T. S.

* * * *

Trouble with Traveling Cranes—I am having trouble with two traveling cranes which run on the same track and are used for loading and unloading stone in a mill. One crane is rated at 20 tons and the other at 30 tons. Each crane has two slip-ring motors of about 20-hp. rating, which operate at 220 volts, sixty cycles and are controlled by General Electric starters. When both cranes are in operation the hookers on the ground get a shock every time they touch the chains which are used to carry the load. When either one of the cranes is idle, the men do not get a shock. I have tested out all circuits with a magneto and was not able to find any indications of trouble. I shall appreciate it very much if any of the readers of INDUSTRIAL ENGINEER can tell me how to find this trouble.

Bloomington, Ind. H. M.

* * * *

Why Do These Commutators Turn Black?—I am experiencing a great deal of trouble from blackening of the commutators on two G. E. belt-driven, type ML, compound-wound, 125-volt, 950-r.p.m., 13 kw., d.c. generators which are used as exciters. After smoothing with sand paper, it is only a matter of a few hours until the commutators are in the same condition again. I have tried turning the commutators in a lathe and undercutting the mica, polishing, sanding, using Ideal commutator stone and tightening the commutator. Also, I have used four different grades of brushes and am now using Speer E-25 brushes. There is no sparking at all under varying loads. The setting of the brush holders was changed from leading to trailing and I found that they worked best leading. I have tried the brushes at different angles and found that the best results were obtained when they were set at about 80 deg.

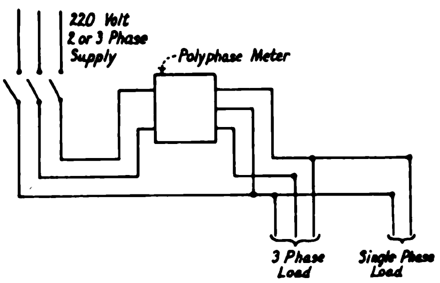
We wipe off the commutators once each day with a dry piece of canvas. I have checked the brushes for the neutral position. The tension on the brushes is 1½ lb. per sq. in. The temperature seems normal except when the commutators get very black as they will do if they go about a week without sanding. These exciters are only two years old and have been in actual service about one year each. I have had this trouble from the start.

I shall appreciate it very much if some reader of INDUSTRIAL ENGINEER can tell me what the trouble is and how I may cure it.

Woodward, Okla. H. J. A.

* * * *

Single-Phase Load on Polyphase Meter—Will some reader of INDUSTRIAL ENGINEER please tell me what will be the difference, if any, in the real power consumption as compared with the meter reading when a single-phase load and a polyphase load are taken from one polyphase meter, as shown in the diagram. The polyphase load seems to



be registered correctly, but will the meter register too much when single-phase power is used? If so, would the same result be obtained on both two-phase and three-phase circuits?

Northampton, Mass. L. G. D.

* * * *

Trouble with Collector Rings of Turbo-Generator—We have a 2,300-volt, 60-cycle, 750-kva. three-phase, 3,600-r.p.m. generator driven by a steam turbine. We are experiencing trouble with one of the collector rings carrying direct current for excitation. This ring develops flat spots and what appear to be burned places all around it. The other ring has a fine polish without these spots and flat places. We changed the leads from one ring to the other and the spotted ring was trued up and polished. Then the ring that was first in good shape developed spots and flat places in the first two days after the leads were changed. The brush tension and brushes have been checked and we do not believe that the trouble is due to the brushes, as we are using the manufacturer's brushes. The proper exciting current is maintained and the rings seem to be true, although two years ago one of the rings became very hot and had to be reground as it was a little out of true. These rings are subject to much coal dust and oil vapor, but as the different rings spot up and have flat places all around them at about the same distance apart with the changing of the leads, I do not believe it is due to dirt. I should like very much to hear from others who have overcome trouble of this sort.

Zeigler, Ill. E. P.

Answers Received To Questions Asked

In the July issue of INDUSTRIAL ENGINEER S. S. gives a sketch of an iron bracket or fixture which he contemplates using to support two sets of feeders, and asks if there is likely to be any inductive or other troublesome effect. I can see no reason for not using this fixture, as feeders supported on the cross member will be in the same situation as if they were run through a short piece of large diameter conduit, while supporting the other feeders on the outside of the bracket will be, in effect, the same as supporting them on a beam or girder, as is commonly done behind switchboards and in other station work.

Denver, Colo. JOHN E. HOLTMAN.

* * * *

Alarm System to Indicate Hot Bearing—We have had considerable difficulty on some heavy pressure rolls due to bearings getting too hot before they were discovered. I have heard that it is possible to use an alarm system of some sort for indicating when bearings get beyond a certain temperature. Can any readers tell me how a device of this sort may be made and installed?

Gary, Ind. L. M. C.

In answer to the question asked by L. M. C. in the June issue of INDUSTRIAL ENGINEER, I would refer him to the advertisement inserted by The Automatic Reclosing Circuit Breaker Company, Columbus, Ohio, on page 86 of the advertising section of that issue. This describes their type TR thermal relay which I am sure can be successfully applied to L. M. C.'s problem. I would suggest that he correspond with the above company, stating his problem, and believe that they would be glad to work out a suitable alarm system which would operate when the bearings reach a certain temperature. I would like to say here that I find INDUSTRIAL ENGINEER to be a reliable source of information on the problems of both operating and repair men, and I would not miss an issue for anything.

Birmingham, Ala. GRADY H. EMERSON.

* * * *

In the June issue L. M. C. asks for an alarm system for hot bearings. This might be accomplished by installing a battery and bell between the lower half of the bearing and the shaft. Connection to the bearing should be made by soldering, and to the shaft with a car-

bon or copper brush. The upper half, or cap, of the bearing, should be separated from the base by insulating shims, and the cap bolts insulated also. Where a perfect oil film exists between the shaft and the cap, insulation would not be necessary.

The operation would be as follows: With the shaft at rest there is, of course, metal-to-metal contact between shaft and bearing. In this condition the bell would ring unless the circuit were kept open by means of a switch. With the shaft running, an insulating film of oil is formed between shaft and bearing and the current would be interrupted. Should the oil film be broken and lubrication destroyed, the circuit would be closed and the bell would ring.

Should L. M. C. try this scheme he should, as his share to this contribution, report the results to Practical Pete.

Kansas City, Mo. C. O. SANDSTROM.

* * * *

Answering L. M. C.'s question in the June issue, I would suggest that a thermo-couple be placed in the bearing shell, or attached to it in such a way that it will be directly affected by the heat. The leads should be connected to a pyrometer, an instrument which registers the temperature in degrees. On the scale of the instrument place a small contact at the point where it is desired to have the alarm sound. The needle or pointer will be the other contact. To these contacts connect a battery circuit with a small relay in series. The relay must have a movable contact and should be connected to a 110-volt lighting circuit, with a bell, horn, lamp or other signaling device in series. A small electro-magnet with an armature bearing a contact may be used in place of the relay.

As the bearing heats up during operation the indicator of the pyrometer will move across the scale so that the temperature can be read in degrees at any time. When the maximum allowable temperature is reached the contacts on the scale will close, which will cause the relay to be energized and close the alarm circuit. The leads from the thermo-couple to the instrument should be as short as possible in order to keep the resistance down.

Seattle, Wash. PAUL E. THOMAS.

* * * *

Selection and Application of Carbon Brushes—Can any of the readers of INDUSTRIAL ENGINEER give me any information on how to choose and properly apply the various grades of carbon brushes? I should like to know how a practical man can by inspection and simple tests choose a suitable brush for a job or determine what application a certain brush is most suitable for. I have seen references to the electrolytic action between brass collector rings and carbon brushes and should like to know the cause of this action and if there are any means of overcoming it.

W. A. P.

Smooth Rock Falls, Ont., Can.

Referring to the inquiry by W. A. P. in the June issue I think that the best thing he can do is to get information from the brush manufacturers.

In general, however, a hard, dry carbon brush is best for high voltages, say over 230 volts, and for machines with high voltage between segments, and not many segments in the commutator. They are good also where there is poor commutation, due to excessive armature reaction and consequent shifting of the commutating plane or neutral point.

Medium carbon brushes, or carbon brushes containing a lubricant, or a mixture of carbon with graphite, cannot be used on the higher voltages because the soft particles rub off and ignite from the current caused by the voltage between segments. They can be used to advantage on some machines which have low speed and large commutators, which will have a low voltage between segments.

In regard to the electrolytic action between rings and brushes, I have had some experience with this but found that it occurred during the peak of the wave and only when one set of brushes was used. By putting on another set in parallel, but 90 deg. from the first set, I found that the trouble vanished. The second set of brushes was easily installed by putting another brush holder on the same stud but pointing in the opposite direction, which separated the brushes the distance of twice the length of the holder.

Boston, Mass. EDWARD A. GIBBS.

* * * *

In reply to W. A. P.'s inquiry in the June issue regarding the selection of carbon brushes, the first step is to learn the properties and uses of the four classes of brushes as follows: carbon-graphite, electro-graphitic, natural graphite, and metal-graphite. The carbon-graphite class is usually the least expensive. The various grades of brushes in this class are hard and strong with some abrasive action, and are adapted for flush mica generators or motors where commutation is not severe, but where the mechanical service is strenuous. A typical application is the series-wound crane motor with its frequent stopping and reversing. The electro-graphitic class has more favorable electrical properties, but has not the rugged physical characteristics of the first class. Most of the grades in this class are entirely non-abrasive and accordingly give better results on slotted commutators. These grades are used on machines where commutation is severe and where the current per square inch of brush cross section is high. Typical applications are the d.c. side of rotaries and heavy-duty, compound-wound motors with undercut mica. Natural graphite brushes are used for still higher speeds and current densities where very soft brushes are needed to overcome chattering, as on turbo-generator field rings. Metal-graphite brushes have very low contact resistance and very high carrying capacity. On account of the former characteristic they are used on low-voltage machines such as electric trucks to minimize the voltage loss; due to their ability to carry as much as 150 amp. per sq. in. they are invaluable for applications such as rotary collector rings.

After determining which class of brush should be applied to a machine the proper grade can be selected by noting the following machine conditions: current density in the brushes (the load current divided by half the number of brushes × the width × the thickness); peripheral speed of the commutator (.262 × diameter × r.p.m.); the extent that commutation is a problem (interpole machines have less severe commutation than non-interpole); the condition of the commutator, whether undercut or flush mica.

Select a grade with a rated carrying capacity at least equal to the current density in the brushes; short overload periods will be taken care of. The recommended maximum surface speed of this grade should not be less than the peripheral speed of the commutator. If the machine is non-interpole or has severe commutating characteristics the grade should have a fairly high contact drop to suppress the reactance voltage; otherwise a lower contact drop grade should be used to reduce the voltage loss. Undercut mica machines should use a grade with no abrasive action; flush mica machines should use a grade with enough abrasive action to keep the mica flush with the bars.

The only accurate test to give a brush is an actual service test. It is difficult to choose the proper brush by inspection, since the average individual cannot readily distinguish any marked difference in the various grades. For this reason it is much easier to choose a brush to fit a particular machine than it is to choose a machine to fit a certain brush.

There is an electrolytic action between brass collector rings and carbon brushes due to the fact that the current passing between them causes an unstable condition. The negative brushes will show specks of copper which have been deposited from the ring and the positive ring will show a carbon deposit from the brushes. Heat increases the electrolytic action and, accordingly, a brush with higher carrying capacity or lower friction may remedy the situation to some degree.

Corliss Carbon Co. L. J. KERLIN.
Bradford, Pa.

* * * *

In answer to W. A. P.'s question in the June issue, I do not know of any simple tests to determine the suitability of carbon brushes. The selection of brushes depends on the character of the service; that is, whether they are to be used on slip rings or commutators; the class of motor, such as mill-type, traction or stationary; and so on. Also, it makes a difference whether the motor, if d.c., has a milled or unmilled commutator. The current-carrying capacity must likewise be considered.

The National Carbon Co. recommends from 1¾ to 2¼ lb. per sq. in. brush pressure for slotted commutators on stationary motors and generators operating under average conditions, 2 to 3 lb. per sq. in. for mill and elevator motors, 3 to 5 lb. per sq. in. for crane motors and 4 to 7 lb. per sq. in. for traction motors. For use on undercut commutators they recommend the following grades: for high-speed rotaries and turbo-generators, peripheral speed above 5,000 ft. per min., Nos. 257 and 634; for stationary motors, generators

and rotaries with peripheral speed below 5,000 ft. per min., No. 255; for mill and elevator motors, No. 401; for crane motors, No. 401 or No. 407; for railway or traction motors, Nos. 203, 222, 255, 401, 402, 407.

For motors with unmilled commutators an abrasive brush should be used in order to keep the mica worn down flush with the commutator bars. In general, carbon and graphite brushes are used for average applications; pure graphite brushes are used to secure high current capacity with lubricating qualities, and carbon-metallic brushes are used for slip rings.

I believe W. A. P. could secure information on the electrolytic action of carbon brushes and brass slip rings from the manufacturers of carbon brushes, who have, I presume, means of determining such action. The testing of brushes calls for much experimenting and I am sure that the reliable brush manufacturers carry on these experiments.

Birmingham, Ala. GRADY H. EMERSON.

* * * *

Winding Data for Transformer of Rectifier—Can some reader of INDUSTRIAL ENGINEER tell me how many turns there are on the transformer of a 5-amp. Tungar rectifier? I dismantled my rectifier some time ago and have lost the winding data.

Valparaiso, Ind. A. T. M.

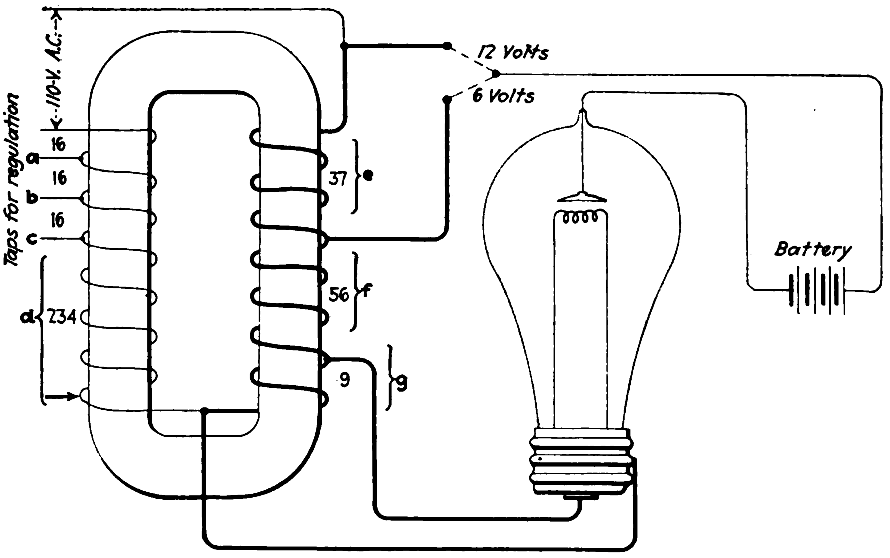
In answer to A. T. M.'s question in a recent issue, I am giving the winding data for the transformer of a 5-amp. tungar rectifier which can be used on a 110-volt alternating current circuit for charging a storage battery at six or twelve volts. The winding is the same for 25 or 60 cycles, but the core is different.

The diagram shows the number of turns and the method of connection. Sections (A), (B), (C) and (D) are wound with No. 16 wire; (E) and (F) are wound with No. 10 wire and (G) is wound with No. 6 wire, or rectangular wire of the same area.

It is best to wind sections (E) and (F) first, and wind (G) on top of them.

Winding data for 5-amp. rectifier.

The numbers opposite the sections of the winding give the number of turns in each section.



The sections should be wound carefully in layers on account of the small space between the core legs.

Duluth, Minn. FRED LARSEN.

* * * *

What Causes This Motor to Spark at the Brushes?—I have a 35-hp., four-pole, shunt-wound motor that drives a fan. The armature has seventy coils, lap-wound. Under load this machine draws 280 amp. at 115 volts and has always sparked viciously. The brushes are of the Bayliss type and I find the neutral point with a voltmeter as closely as one can. When I stone the commutator down the motor runs satisfactorily for a day or so and then sparking begins and the commutator develops low bars and seems to flatten or sink.

I am wondering if this armature was designed for a four-pole machine, as it has seventy bars and coils. This number is not divisible by four without a remainder and thus throws the neutral point in the center of a bar. I shall be very grateful if some reader can explain what causes the sparking and tell me how I can overcome it.

New York, N. Y. C. E. K.

In answer to C. E. K. in the March issue, the commutator of this 35-hp. motor likely has loose bars, which lower just enough to catch the toe of each brush. As the brushes are of the Bayliss type they are set with the toe against the direction of rotation. The bolts at the end of the commutator should be drawn up tightly and the bars turned down in a lathe. If the motor is not overloaded and each stud carries its full quota of brushes with sufficient contact area, all set at the proper angle, the sparking will not appear. The Bayliss Co. will gladly recommend the proper size and number of reaction brushes for a 35-hp. motor, if our correspondent will give them all the data needed, as to motor and load.

New Britain, Conn. H. S. RICH.

* * * *

In reply to C. E. K.'s question in the March issue of INDUSTRIAL ENGINEER, if the motor pulls a current of 280 amp. at 115 volts, it is evidently overloaded, or else has an efficiency of only 81 per cent. A motor of that size should have an efficiency of somewhere near 95 per cent and would then draw 239 amp. at 115 volts.

It would be well to take a reading of the voltage at the motor terminals to ascertain for sure whether there is a full 115-volt supply. A low voltage would cause the motor to take an increase in current. From the description of the trouble given, the indications are that there is either a high-resistance connection or an open circuit, usually in the armature circuit.

If only certain bars seem to flatten or sink, the trouble is usually a high-resistance connection where the riser connects to the commutator bar or where the armature conductor connects to the riser or commutator bar. Or the coil connecting to the sunken commutator bar may be found to be open.

However, if all the bars seem to burn the brushes may not be making good contact with the commutator or may not be of sufficient carrying capacity, or the field poles may not be of equal strength.

Muncie, Ind. GEORGE CROPPER.

* * * *

Lining Up Gears and Pinions—I would like to know some of the methods that readers of INDUSTRIAL ENGINEER use in lining up spur and bevel gears. How can I tell whether the gears and pinions are meshing too deeply or not deeply enough? I know how it should be done theoretically, but I would also like to know how it is done practically, out on the job.

Youngstown, Ohio. H. H.

Answering the question by H. H. in the May issue of INDUSTRIAL ENGINEER, first line up the shafts in their approximate position horizontally, with a spirit level placed on some part of the shaft. The level may be placed near the ends, with the pinion and gear removed. To line them both at the same height place the level across both, if the shafts are of the same diameter.

If they are not of the same diameter it will be necessary to shim under the level on the smaller shaft an amount equal to one-half of the difference in the diameter of the two shafts. If the level is not long enough to reach across the shafts a straight-edge may be placed under the level. The shims used should be of uniform thickness and perfectly flat so that a sidewise movement of the machines will not alter the horizontal line-up. Put the gears on and if necessary to move the machines mark the shims so that they will go back in the same place.

Set the gears in mesh as closely as possible with the eye and bolt the machines down firmly, using two bolts or lag screws 1-16 in. or 1/8 in. smaller than the holes in the base. Then take two pieces of string or wire solder, one on each end of the teeth, and run them in between the gears at a right angle to the teeth, turning the machine by hand or with a bar. The thickness of the pressed portion of the two pieces of solder may now be measured by a micrometer or calipers. If they are the same thickness the gears may be considered to be lined up accurately enough for any ordinary conditions. If both pieces of solder are not pressed alike one machine should be moved slightly and the test repeated until they come right.

The thickness of the solder is also an indication of the correct spacing or clearance. The formula for clearance is 0.157 ÷ diametral pitch. Feelers may be used in place of the solder to

check the clearance if the gears are large enough to allow this to be done.

It is well to recheck each shaft for horizontal line-up and if this is all right the remaining bolts may be put in, full size, and the machines doweled, if practicable, to insure future alignment.

If the gears are very small the solder may be flattened out before running it between the teeth. If large gears are being tested two or more pieces of solder may be twisted tightly together like a rope. If care is taken to line the shafts perfectly horizontal in the first place the method described above will be found to be very accurate, requiring a minimum of tools, mistakes and figuring. CHESTER A. WILLIAMS.

Electrical Department,
Providence Gas Co.
Providence, R. I.

* * * *

Replying to H. H.'s question in the May issue of INDUSTRIAL ENGINEER, most of the gears made today are cut involute, which gives a true rolling motion of one tooth upon another, regardless of the depth of engaging. However, where a gear train is subject to reversing or when it always revolves in the same direction but the driven wheel shaft is braked in stopping, backlash is objectionable and causes breakage due to crystallization of the teeth.

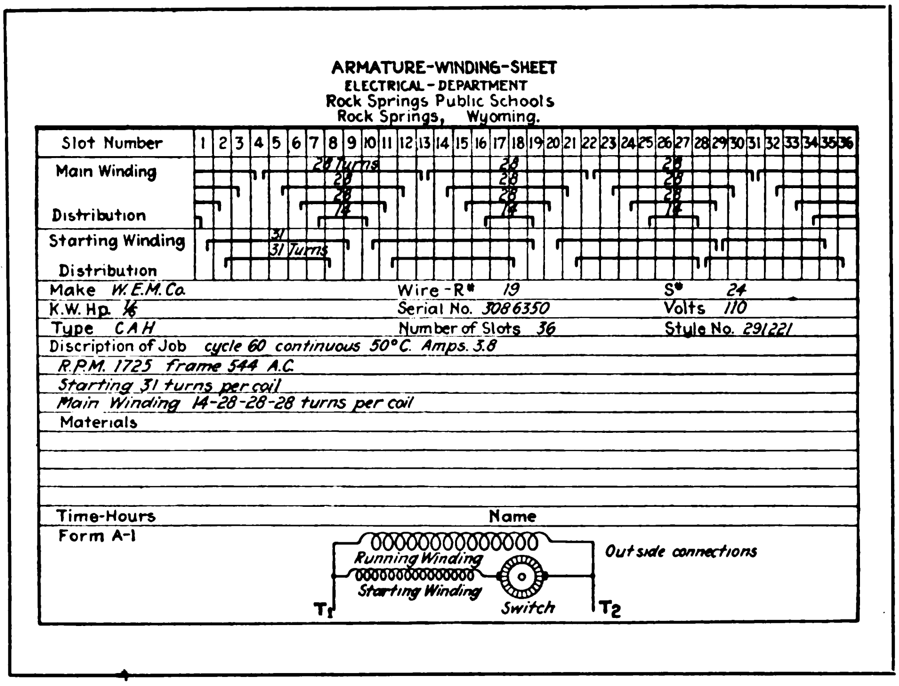
Cut gears should be meshed as closely as possible by bringing them together square across the face. Using a strip of tissue paper about 0.002 in. thick and a little wider than the face of the gears the alignment and depth of the teeth engaged can be checked. The paper, a few inches long, is placed in a tooth and the gears slowly rotated by hand, pulling the paper through between the teeth. By observing the imprint on the tissue paper, a little experience will soon show if the tooth bears against the one adjacent over the full face and depth. If an extremely accurate meshing of the teeth is required, thinner paper may be used and the gears closely adjusted to produce a slow humming noise when operating at speed. Then, by mixing some fine powdered emery, No. 00 or No. 0, with a good lubricating oil and using this between the gears, operating them at slow speed, a very good meshing of teeth and quiet running will be obtained. E. H. LAABS.

Engineer, Printing Equipment Dept.,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

* * * *

Winding Data for Washing Machine Motor—Can some reader supply me with the winding data for a Westinghouse washing machine motor? According to the nameplate this is a 60-cycle, 1,700 r.p.m., motor, 220-110 volts, 2-4 amp. The laminations are 6¼ in. in diameter; the inside bore is 3½ in. and the axial length of the core is 2⅝ in. There are twenty-four slots, ¾ in. deep and ⅜ in. wide. The teeth are ⅛ in. wide at the top and ¼ in. wide at the base. This motor employs a starting winding. I shall appreciate any information which you can give me.
Hercules, Calif. S. McP.

Replying to S. McP.'s question in the March issue for the winding data of a washing machine motor, the accompanying record card gives the data for a similar 36-slot motor, from which the



Record card for winding data of Westinghouse washing machine motor.

data for the 24-slot motor can be worked out. CHARLES F. CAMERON.

Instructor, Electrical Dept.,
Rock Springs High School,
Rock Springs, Wyo.

* * * *

Rewinding 6-Volt Motor for 110 Volts—I have a Gray & Davis 6-volt d.c. motor which I would like to convert into an electric drill to operate on a single-phase, 110-volt, 60-cycle circuit. Is it possible to rewind this motor? It is equipped with a brush rocker and brush spacing device.
Logansport, Ind. L. E. G.

L. E. G. states in the May issue that he wishes to rewind a 6-volt, d. c. motor to make a drill for operation on 110 volts, 60 cycles. An article by the writer in the May issue will suggest why this is not worth trying. Specifically the reasons are: (1) The field frame would become very hot because it is not laminated and the alternating magnetic flux would set up destructive eddy currents. (2) The number of commutator bars satisfactory for a 6-volt motor is not at all suitable for a 110-volt a. c. series motor. (3) Very little power would be developed during the few minutes that the motor would operate before burning up.

E. L. CONNELL.
Electrical Engineer,
Van Dorn Electric Tool Co.,
Cleveland, Ohio.

* * * *

Why Does This Watt-Hour Meter Run Backwards?—I have a 150-kw. motor-generator set driven by a synchronous motor which is operated from a 2,200-volt line. When the set is started why does the watt-hour meter run backwards? The fact that it does run backwards surely does not mean that no power is used in starting. (2) When this machine is running at no-load should the ammeter on the exciter be adjusted so that the watt-hour meter runs very slowly, or so that it stands still? (3) When the watt-hour meter runs backwards, as mentioned, what is the cause of the trouble and what will be the effect? Will it harm the machine in any way? I shall appreciate any information which your readers can give me on these points.
Beaverdale, Pa. M. A. L.

Answering M. A. L.'s question in the May issue, (1) the fact that the watt-hour meter runs backwards when the motor-generator set is started is a definite indication that the meter is incorrectly connected. Assuming that the meter is three phase, it means that one of the elements should have its connections reversed. Of course, power is used in starting as well as when the motor is operating under load, but the fact that the power factor is low and one of the meter elements is reversed causes the element which is revolving, or tending to revolve, in a backward direction to overcome the tendency of the other meter element to move ahead, and thus results in a backward rotation. It is also assumed that the meter is of the polyphase type, that is, all in one case, with the elements on one shaft. Reversal might be caused by a blown potential fuse in one of the meter elements, but I presume that this point has been checked.

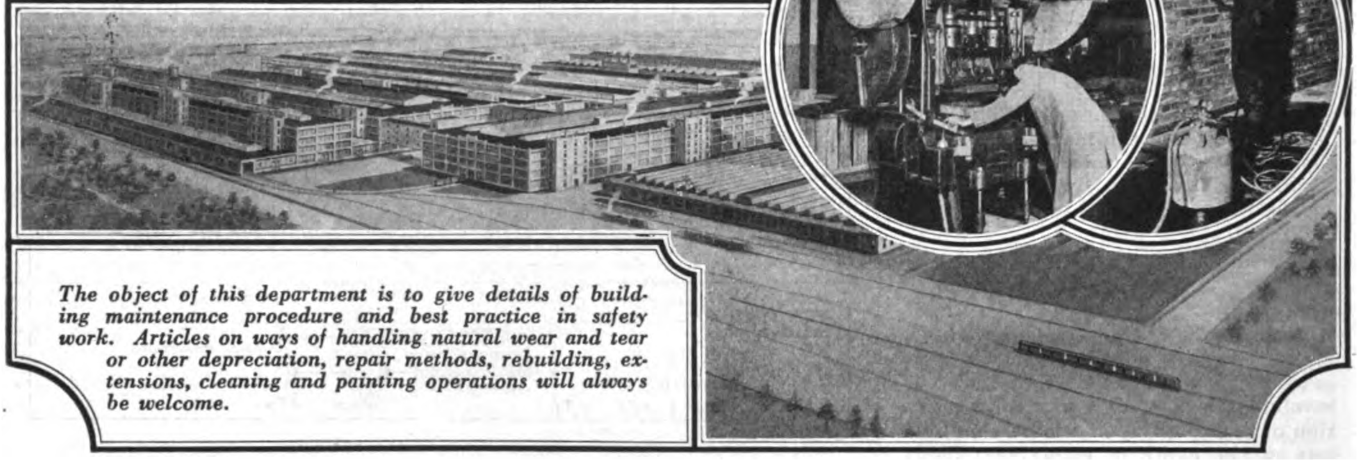
(2) At no-load the field rheostat of the motor should be adjusted so that the motor current is at its minimum value; that is, either lowering or raising the exciter current from this value will cause the motor current to increase. With the motor current at its minimum value the watt-hour meter will run very slowly, but will never stand still if it is correctly connected.

(3) As stated in (1) the meter runs backwards because it is incorrectly connected and the only real effect will be to give a wrong registration of the energy consumed.

It is assumed in the foregoing that there is an ammeter available so that the current put into the motor at 2,200 volts can be read. Definite assurance of the correctness of the watt-hour meter connections can be obtained by operating the motor either at no-load or under load at a number of values of field current which will, of course, be the same as the exciter current if the machine is direct-connected.

C. OTTO VON DANNENBERG.
The J. G. White Engineering Corp.,
New York, N. Y.

Building Maintenance and Plant Safety



The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Special Constructed Foundation for Vibrationless Operation

THE PROBLEM of building a foundation which would not transmit any vibration or hum into the building was successfully met in the installation of a steam turbine in a large New York City hotel. Usually preference has been given to reciprocating engines for such installations where noiseless operation is required. The engineers of this hotel preferred to use turbines, if it was possible to do so, and were convinced that if the machines were properly installed, their slight hum could be suppressed. The method used to construct the foundations may be of interest to others who might be called upon at some time to solve a similar problem in a school, or hospital or office where quiet operation is desired.

The equipment consists of three 200-hp. non-condensing Westinghouse turbines, each of which drives a 200-kw. 250-volt, direct-current Westinghouse generator. Special attention was given to the turbine foundations in order to prevent the vibrations of these high-speed machines from being transmitted to the structure of the hotel. The foundations were to consist of a concrete block which was to rest on a 2-in. bed of sand and was to be separated from the building's foundations by a thick layer of cork on three sides and an open space on the fourth side.

In spite of these precautions, however, the turbines could be heard in many parts of the hotel as soon as they were started up. The engineers made a thorough examination of the installation and soon located the trouble. In pouring the concrete block, the cement had leaked out into the cork and the sand, and had formed a solid mass, thus destroying the sound-absorbing cushion that had been prepared.

These defective foundations were therefore torn out and new ones, as shown in the accompanying sketch, were laid. The bed rock was levelled, brought to an even surface with cement and the four sides enclosed with 8-in. brick walls up to the floor finish, the walls and floor of the "box" were then waterproofed on the inside with five-ply felt and pitch. A 2-in. layer of hair felt was placed on this bed, with a 2-in. layer of compressed cork on top of that. Then came another layer of felt which was covered by alternate layers of cork and felt so as to make an insulated box on the inner wall of the foundation pit.

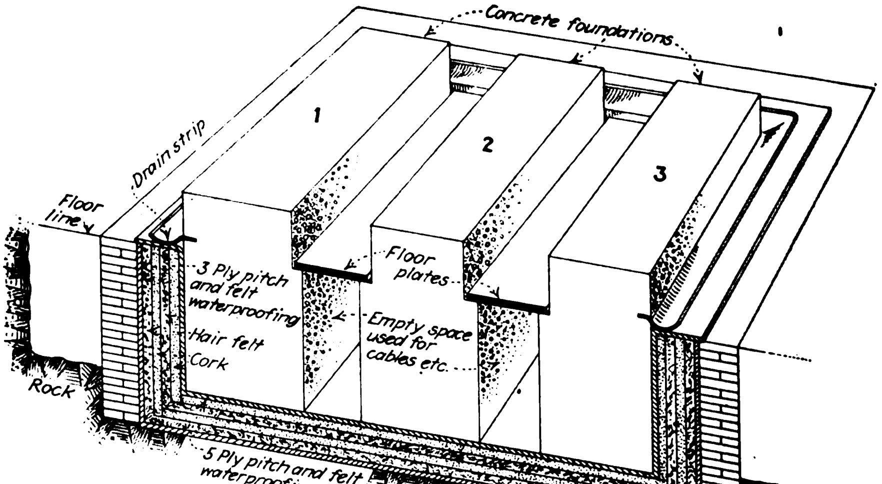
These same six layers of insulation were carried up the face of the brick walls to the floor level as well as on the bottom. The interior surface was again waterproofed with five-ply membrane felt and pitch which was carried over the top edge of the side-wall insulation. Into this insulated and waterproof box, concrete blocks were carefully poured. These extended over the side wall insulation, with a brass drip cast into the foundation.

East Pittsburgh, Pa. H. H. LUPINSKI.
Westinghouse Electric & Mfg. Co.

Wood Blocks Prevent Accidental Closing of Switch

AS A MEANS of preventing knife switches from being closed when repairmen or inspectors were working on motors or other equipment, I used to employ little blocks of hard wood which had a hole drilled in them and were then chiseled out to fit well in the clip of the switch, and tightly enough so that they would not fall off. When a machine was to be shut down for repairs, I would slip these blocks on each clip and as an extra precaution would close the knife blade against the blocks.

When making these blocks the hole should not be drilled all the way through, but only as deep as the clip.



Details of the construction of a vibration-proof foundation.

When it was desired to insulate a steam turbine foundation from the building so that no vibration would be transmitted this insulated box was constructed and the concrete poured into it. The inner waterproof coating is five-ply instead of three-ply as indicated here.

A separate set of blocks is, of course, required for the various sizes of switches.

A piece of string can be fastened on each block and the sets of various sizes kept together on nails in the maintenance department.

Oakland, Calif. S. H. SAMUELS.

Suggestions on Making Shop Floors That Last Under Trucking

FOR MANY purposes new and even concrete floors are most satisfactory for the shop, particularly when there is much transportation of materials. It is not so satisfactory a floor as regards installation of machine equipment or where working on breakable materials, such as castings, which may be dropped and broken. The wear on a concrete floor, by truck wheels, however, eventually occurs in an amount depending on the preliminary treatment of the concrete. Any small crack or slight crevice causes the steel truck wheels to bump and under these circumstances ordinary concrete tends to crumble rapidly.

Floors worn to this condition are expensive to repair because resurfacing with a rich mixture of cement is possible only by removal of one to two inches of the top surface to obtain a bonding surface sufficiently clean and clear of grease to which the top coat will adhere and have body enough to withstand pounding of the truck wheels. While this method has been used in one large plant, it was found necessary, after three years, to remove the concrete in the path of the trucking for the entire depth and rebuild that section of the floor.

To prevent this rapid wear another plant has adopted for the concrete floor a surface treatment which consists of several coats of boiled linseed oil thinned with gasoline. This mixture apparently penetrates the pores of the concrete and forms a gummy bond which resists wear, as the floor has given six years of service and still is in good condition. An additional advantage is that this floor is practically free of dusting, which is objectionable in that it is detrimental to open machinery.

Wooden floors laid over concrete have protective qualities which are desirable in many machine shops. Breakage of parts dropped on them is infrequent; they are sound deadening to a large extent and considerably more comfortable from the workman's standpoint. Ordinarily wooden floors wear for long periods when the trucks are run mostly in line with the grain of the wood. Splintering is only apparent with heavily loaded trucks or after long use. Oak flooring will splinter more rapidly than maple, which is possibly the most desirable of any of the woods for shop floors. In placing shop floors, the practice generally is to use a double floor with the upper section laid at right angles or across the under surface. To repair any splintered floor, the top section of the floor is removed and replaced with new material. When it is evident that truck paths are across the grain, thus causing rapid splitting or splintering of the wood, the floor may be repaired by placing the top section longitudinally to the truck paths, regardless of the sub-flooring.

In some shops where the combination of wear and weather at the edges of the entrance doors causes rapid destruction of the wooden flooring a special concrete mixture has been adopted with considerably more success than was had with the wood. This repair consists of the entire removal of the wood, laying a 10-in. tamped cinder bed and filling for a depth of 8 in. with cement, iron dust and sand in the proportions of 20 parts of iron dust to 100 of cement and 200 of sand. This cement has shown remarkable resistance to wear, is waterproof and provides a good gripping surface for rubber-tired motor truck wheels, and the steel wheels of the hand trucks. Likewise it affords a dependable footing for stepping on in wet weather, as it is not slippery at any season.

Washington, D. C. G. A. LUEBS.

[NOTE: The Editors would appreciate comments from readers on their experience in repairing wooden and concrete floors to take care of trucking wear. Should trucking be with, across or diagonal to the grain of wooden floors?]

Practical Safety Pointers and Possible Penalties Inflicted on Those Who Take a Chance

By H. S. RICH

New Britain, Conn,

With his own illustrations.

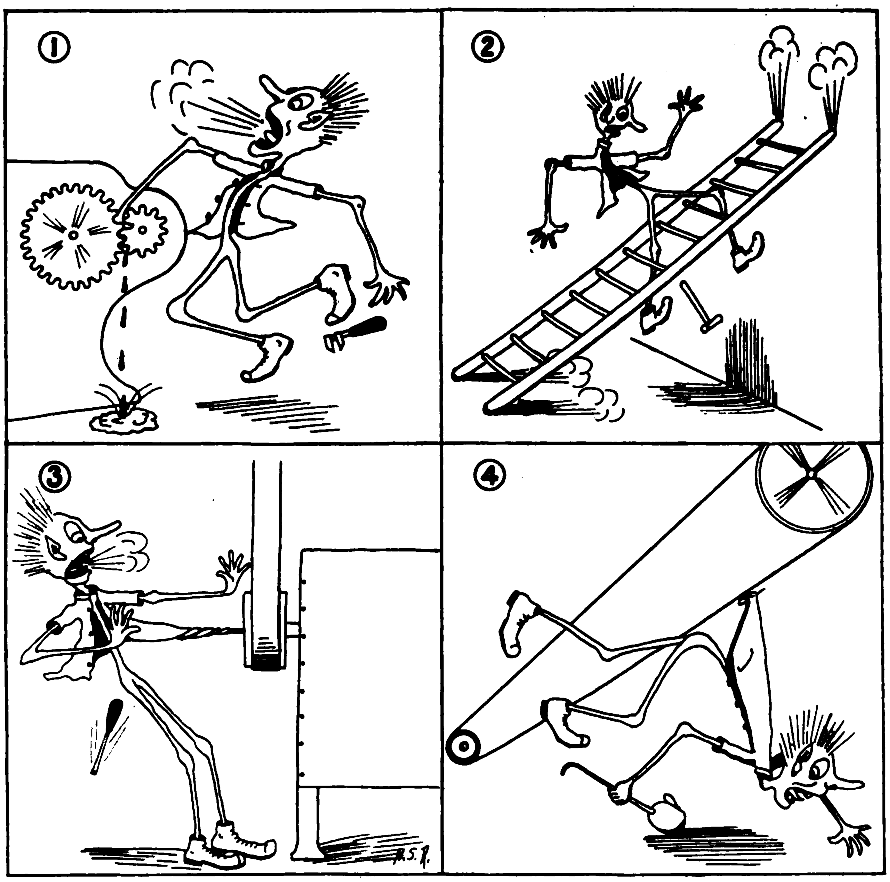
(1) One of the most dangerous things about a plant is an exposed gear on a machine in operation, for when it once gets a hold on a person's limb or clothing there is no getting away from it. A belt on a pulley may slip off or break just as some large obstruction gets caught under it, but not so with a gear; it just grinds and crushes away unmercifully.

An oiler or some mechanic may have his hand resting on a gear, not thinking about how easy it is to get hurt, when suddenly, somebody starts the machine, and quick as a wink, that hand is caught. Keep your hands off gears, even when idle. Gears should be entirely encased with some provisions for opening the guard to be safe.

(2) A ladder without sharp spurs is a risky thing on a smooth, oily or wet floor. A ladder with spurs can be held securely on a smooth floor by resting it on a wide board. A few small nails only are needed to hold it.

(3) A pulley with a protruding key is also quite dangerous, and will wind up a person's clothing in jig time, perchance it gets a grip. Drive keys in until they are tight and cut them off flush or round the end over with a file.

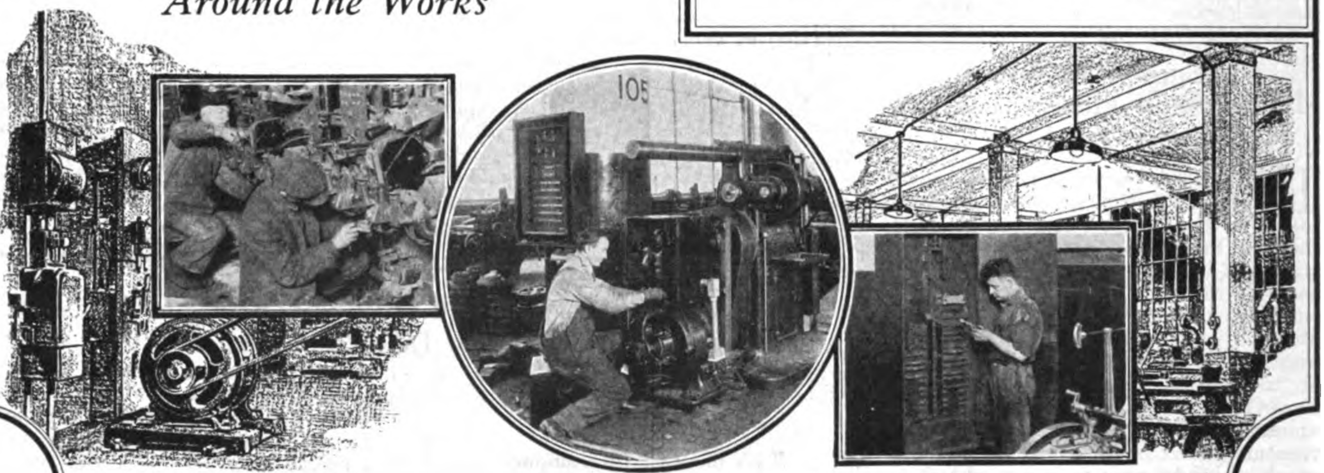
(4) A belt with metal or wire fastenings is liable to get hooked on your clothing or the waste in your hand if in the danger zone. A belt with a loose inside flapping edge will also give your hand an awful rap, while applying belt dressing.



Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Easily-Made Trip Coil For Remote Control Of Motors or Feeders

OFTEN it is desired to stop a motor or open a circuit from a distant point and yet not run heavy leads to the desired point. Also, in the case of a motor driving a group of machines, it is frequently necessary to be able to stop the motors from several different points. If the motor or circuit is controlled by a circuit breaker, the trip coil herein described may prove to be the solution of the problem.

In Fig. 1, the trip coil is shown mounted on brackets below the overload trip latch of the circuit breaker. The plunger of the trip coil rises and hits the latch of the circuit breaker, thus opening the circuit. In Fig. 2 the construction and dimensions of the trip coil are shown. As can be seen, the spool is made of brass. The cylindrical portion of the spool is insulated with three to five layers of varnished cambric and the inside ends of the spool are covered with four or five layers of paper 0.010 in. thick. The spool is wound full with magnet wire. For use on 110-volt supply, use No. 29 wire; for 200-500-volt supply, use No. 32 wire.

The plunger is made of mild steel and has a hard wood extension at its upper end long enough to reach the trip latch of the circuit breaker.

The connections of the trip coil are very simple. One end of the coil is connected to the motor side of the circuit breaker. The other side of the coil is connected to a switch located at the desired control point. The other side of the switch is connected to the motor lead of polarity opposite to that of the line wire in which the circuit breaker is placed. Hence, when the control switch is closed, the trip coil is energized and the circuit breaker opened. The circuit breaker opens the circuit through the trip coil as well as through the motor or feeder; hence as long as the control switch is closed, the circuit breaker will remain open. The trip coil may be controlled from several different points by connecting control switches in parallel with the first one. This feature is of particular value when it may be necessary to shut down the drive in an emergency, for the control switches can be located at convenient points.

The trip coil and switch may be used as a safety feature. When only one control switch is used, it may be enclosed in a box with a hasp and lock on it. With the switch closed and the box locked no one, except the man with the key to the box, can start the motor, inasmuch as the circuit breaker will not stay closed as long as the control switch is closed. This will prevent starting the motor while some one is working on the drive.

I have used this coil for several years and have had very little trouble with it. It can be used on 220, 440 or 500 volts alternating current or direct current without any change in connections or the winding of the coil. For 110 volts, the coil works best with the larger size of wire, No. 29, mentioned above.

Chief Electrician, ERNEST J. FORD.
Kewanee Boiler Company,
Kewanee, Ill.

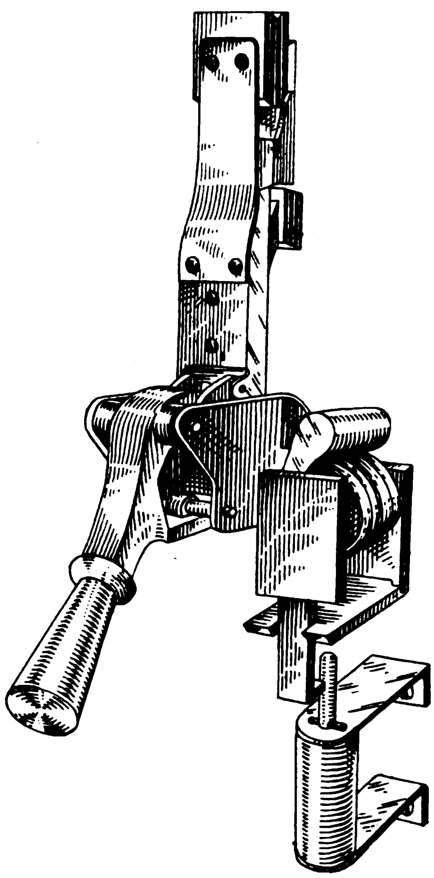


Fig. 1—This trip coil can be easily applied to any circuit breaker.

The coil is shunted across the line through a control switch and when energized the plunger will strike the trip latch and thus open the circuit breaker.

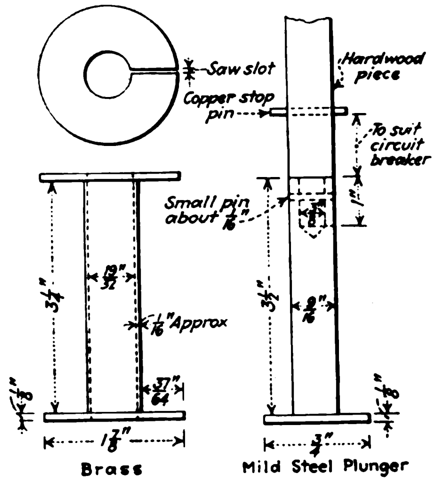


Fig. 2—The spool of the trip coil is made of brass.

The dimensions are shown at the left of the diagram. On the right is shown the construction of the mild steel plunger which is actuated by the coil. At the upper end of the plunger is an extension made of hard wood which should be long enough to reach the trip latch of the circuit breaker.

Keeping Idle Generators Warm to Prevent Condensation

FROM past experience with generator winding breakdowns, C. Monson states in the April number of the Journal of the American Institute of Electrical Engineers that he believes many of these breakdowns have been due to moisture or water getting into the machine, causing concentration of corona on the winding where drops of water were located.

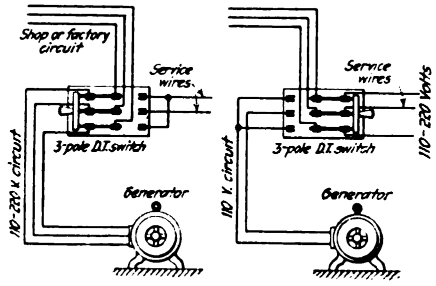
Generators may be shut down frequently from one cause or another, such as lack of load, repairs, cleaning and the like. If the generator when idle is allowed to cool off below the room or ingoing temperature, or if a generator is of the enclosed type taking air from outside the building or from the basement and discharging it to the outside, heating it up by a quick change in temperature either when standing still or when started up with load will result in the condensation of moisture both in the stator and the rotor, the water dripping all over the winding.

This water is the cause of considerable trouble from corona after the generator is started and running with full potential. From tests that have been made it has been found that these drops of water will show fire with relatively low voltage in the coils and that the fire increases in density with increased voltage. It is thus only a matter of time before the winding is injured sufficiently to break down at its weakest point.

To safeguard against this enemy of the generator when idle, it is suggested that the machine be kept moderately warm at all times, slightly above the temperature of the room or ingoing air. This can be done in several ways, such as installing steam pipes in the air entrance or in the shields, by the use of electric heaters or by circulating a current through the windings.

Cutting Over from 3-Wire to 2-Wire Supply

MANY factories are wired for three-wire, 110-220-volt service and have an outside emergency supply which is two-wire, 110-volt. A convenient means for quickly changing from one supply to the other is shown in the accompanying diagram. The scheme shown on the left is for use when the outside emergency supply is two-wire and the plant system is three-wire; the scheme on the right is for use when the outside supply is three-wire and plant generator is two-wire.



By means of the three-pole, double-throw switch, transfer of a circuit may be made from a three-wire, 110-220-volt supply to a two-wire, 110-volt supply.

As can be seen from the diagram, a three-pole, double-throw switch is used, the middle poles of which are connected to the shop or factory circuit which it is desired to transfer from one supply to the other. On the two-wire end of the switch, the two outside switch jaws are connected together and to one side of the 110-volt line. The center jaw is connected to the other side of the 110-volt line. When the switch is closed on the two-wire side, the shop circuit will have 110 volts impressed between the two outside wires and the middle wire.

This will supply all of the 110-volt equipment operated in the shop. If the shop circuit has any 220-volt motors connected across the two outside wires, this system will not, of course, supply them, inasmuch as only 110 volts are available and the two outside wires are of the same polarity. However, on most three-wire, 110-220-volt systems, used in factories, only 110 volts are taken from the wires; consequently, this scheme of transferring from one supply to the other will prove very convenient.

New York, N. Y. DONALD L. HOARE.

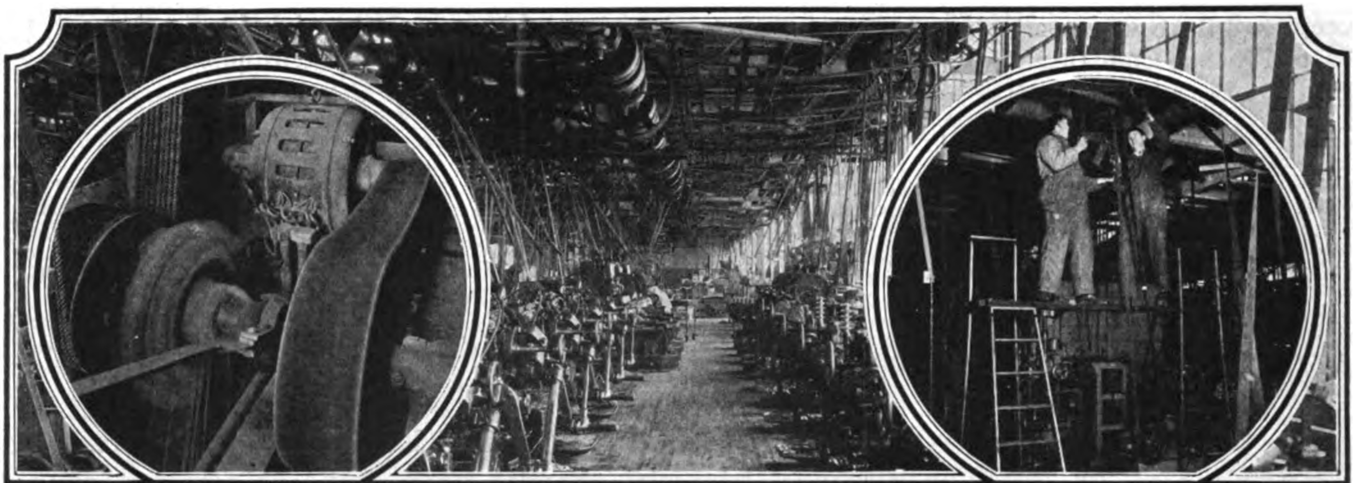
Industrial Applications of Synchronous Motors

OPERATING men in various industries who may be considering the possibilities of the use of synchronous motors to improve their power factor will be interested in the accompanying chart. The column at the left lists the common industries and the headings show the different equipment in each of those industries which is best adapted to the use of synchronous motors. It is interesting to note that in this chart, as arranged by the Electric Machinery Manufacturing Co., Minneapolis, Minn., centrifugal pumps seem to be the type of equipment in the largest number of industries which is most suitable for the application of synchronous motors.

With this chart an industrial man may check the possibilities of the use of synchronous motors.

While this chart shows the equipment ordinarily found in these industries some special occasions may arise where other equipment, which could also use synchronous motors, may be in use in some particular plant. It is always best. however, to refer any installation back to the manufacturer of the synchronous motor for his recommendations.

INDUSTRIES	Air Compressors	Ammonia Compressors	Ball Mills	Blowers	CO_2 Compressors	Centrifugal Pumps	Fans	Frequency Changers	Conveyors	Grinders	Jordans	Line Shafts	Motor Generator Sets	Pulp Grinders	Plunger Pumps	Rubber Rolls	Crushers	Tube Mills
Automobile	●			●			●					●	●					
Brick and Clay						●			●			●						
Cement Plants	●		●	●			●					●						●
Cereal Mills		●				●	●		●	●		●			●			
Cooling					●		●											
Drainage Projects						●												
Dredges						●												
Electric Lt. & Pr.								●					●					
Flour Mills							●		●			●						
Foundries	●			●														
Grain Elevators							●		●			●						
Ice and Refrigeration	●	●				●												
Iron Works	●			●									●					
Irrigation Projects						●												
Lumber Mills												●						
Marble and Stone Works	●											●						
Metal Working	●			●								●	●					
Mines	●					●	●		●						●		●	
Oil Refineries						●									●			
Packing Houses		●				●	●		●	●								
Paper Mills						●					●	●	●	●				
Pulp Mills						●					●			●				
Quarries	●					●			●								●	
Railroad Shops	●			●								●	●					
Rock Crushing									●	●		●					●	
Rubber Mills																●		
Sand and Gravel Works						●			●									
Sewage Disposal						●												
Shipyards	●																	
Steel Mills	●			●		●	●	●				●	●		●		●	
Textile Mills												●						
Water Works	●					●									●			
Wood Working				●								●						



Mechanical Maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Easily Made Device for Pulling Off Pinions and Brake Wheels

WHILE there are many devices on the market that are very convenient for pulling off brake wheels and pinions, here is one that can be made in any machine shop.

It consists of four parts made of steel bar: the jack screw, the cross bar, and the two legs which engage with the pinion or brake wheel. The jack screw shown in the illustration on the left is 1 ft. long and 1⅛ in. in diameter. The cross bar is drilled and threaded to fit the jack screw. The cross bar is made from a steel bar 3 in. wide, 3 in. thick and 18 in. long. If brake wheels larger than 15 in. in diameter are to be pulled, the cross bar should be longer than 18 in. The cross bar is slotted at each end to receive the legs, as shown in the left-hand illustration. The legs are made of steel bar 1 in. thick, 2 in. wide and 12 in. long. The ends of the legs are notched as shown so as to engage with the brake wheel or pinion. Holes 11/16 in. in diameter are drilled in the legs and in the cross bar; these holes permit adjustment of the device to suit the size of the brake wheel or pinion it is desired to pull. Bolts ⅝ in. in diameter are used to fasten the legs and cross bars together.

The illustration at the right shows the manner of using the device. Blocking is put underneath the cross bar to keep it from turning when the jack screw is tightened against the armature shaft. The jack screw should be tightened with a long-handled wrench; a piece of pipe may be put over the wrench handle to make it longer. It often helps to start the brake wheel if the hub is pounded, after tension has been applied by tightening the jack screw. In very stubborn cases, the hub of the wheel may be heated with a blow-torch or acetylene flame.

Chief Electrician, O. C. CALLOW.
Trumbull Cliffs Furnace Company,
Warren, Ohio.

Safety Suggestions for Workers Around Shafting

SAFETY SUGGESTIONS for those who work about revolving shafting are given below. Not only does the observance of these make for personal safety, through the reduction in the number of minor and serious accidents, but it reduces maintenance costs through avoiding loss of time and broken belts. All of these increase plant efficiency.

Don't have pulleys too close together. There should be a space between adjacent pulleys equal to double the width of the wider belt used upon those pulleys.

When a belt is thrown off a pulley to remain off for any but immediate repairs, it should be hung upon a belt perch installed for the purpose. It should never hang upon the revolving shaft.

All belts that are replaced on revolving pulleys should be put on with a belt stick, or pole. If a belt cannot be put on that way, stop the shaft or wait until it is stopped and then apply it by hand at a speed of not more than 15 r.p.m.

Wood pulleys sometimes get chipped; usually one of the laminations only is knocked out. Such jagged edges are as dangerous as projecting set screws and should be filled immediately.

Two pulleys ought never be placed together, unless this is done to make one wider pulley for one belt only. When two belts are run from close-up pulleys, breaking of one belt invariably results in its getting wound up in the other one.

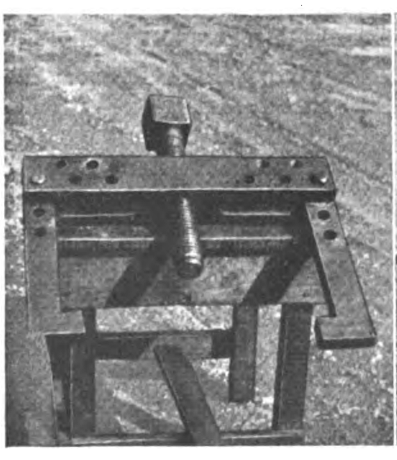
When split pulleys are installed, see that the joint edges are evened up. The overlapping edge at the joint may catch on and tear a belt or cause injury to the hand of a beltman.

Inspect belts periodically and repair broken fastenings and loosened laps.

Do not use a ladder against a revolving shaft unless it has safety feet and top hooks.

Oil all shaft bearings and as many loose pulleys as possible when the shafting is not running.

On pulleys over 16 in. in diameter, which are held by setscrews, protect the screws by safety collars or other



This device for pulling brake wheels or pinions is made from steel bar and is adjustable for the different sizes of wheels or pinions.

guards. The mere fact that setscrews are "within the boundaries of the rim" does not remove the hazard where there is sufficient space between hub and rim for the arm to enter.

Never work about moving shafts with loose clothing, particularly loose sleeves.

Do not thrust arms through spaces of a pulley, even though the shaft is idle; someone may start it moving.

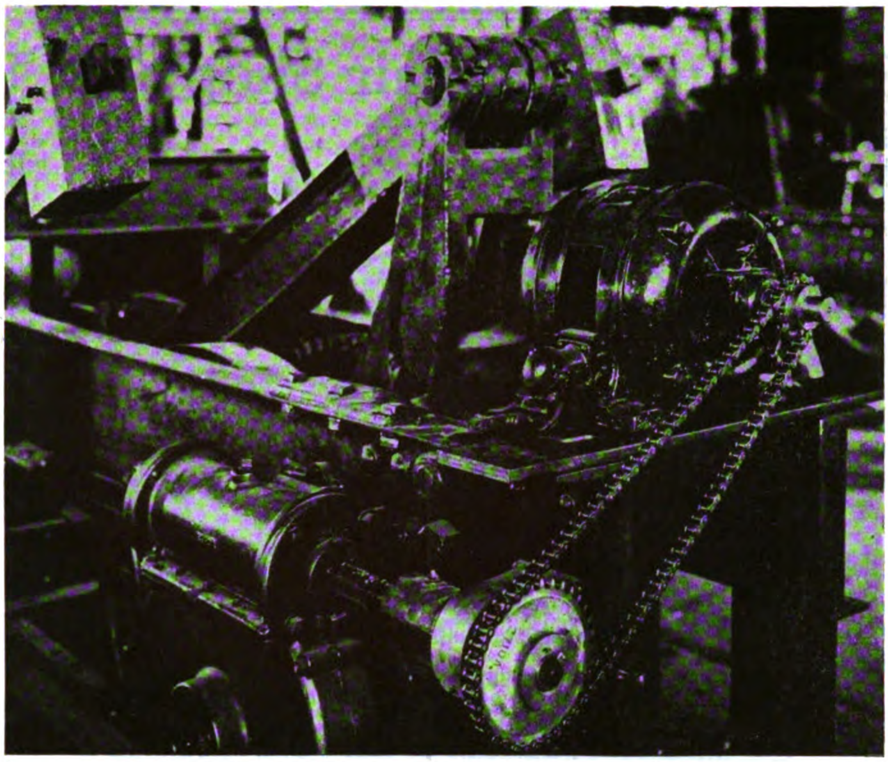
DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.

Roller Chain Solves Unusual Drive Condition

ONE of the recent improvements made in the drive on our balers, used for baling scrap metal, leather, rags, paper, cotton and the like, was to replace the type of chain drive in use on the worm shaft drive with roller chains made by the Diamond Chain and Manufacturing Co., of Indianapolis, Ind. An unusual characteristic of the drive on these balers is the use of high-torque motors which give the chain a terrific jerk when starting and then, as the bale is compressed, the motor slows down until the current is automatically cut off just before it reaches a dead stop. This cycle is repeated every time a bale is made.

Two sizes of balers are used: A small baler on which the maximum chain pull amounts to 600 lb. and a larger baler on which the maximum pull amounts to 1,000 lb. The small motor develops a maximum torque of 70 ft.-lb. and we are using a roller chain with ⅝-in. pitch, ⅜ in. wide. The larger motor develops a 140-ft.-lb. torque and we are using on it a roller chain with ¾-in. pitch, ½ in. wide. The length of chain varies with the different balers but averages 5 ft. The motor sprockets have fourteen teeth and the chain speed runs as high as 1,400 ft. per minute.

This substitution resulted not only in a saving in first cost, but also a saving in maintenance costs. The saving in first cost amounted to $16.75 per baler. This saving of $16.75 per baler plus a saving of $2.00 in the cost of the sprockets, amounts to $5,625.00 per year on our production of 300 machines. In 2½ years of use we have had only one replacement and this was due to letting a piece of wood get between the chain and the sprocket. With the exception of this instance, we have not had a cent's worth of repairs to chains or links.

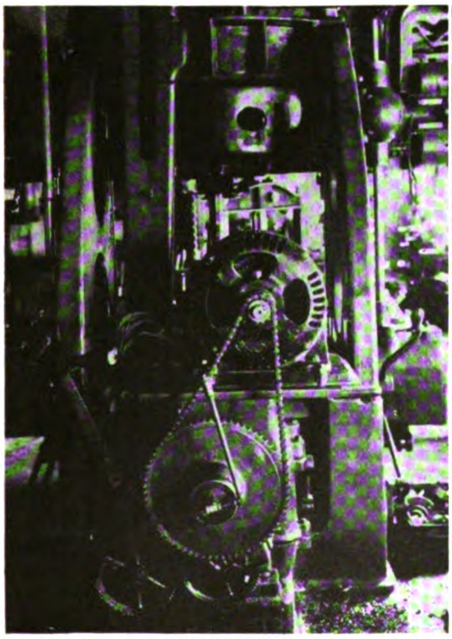


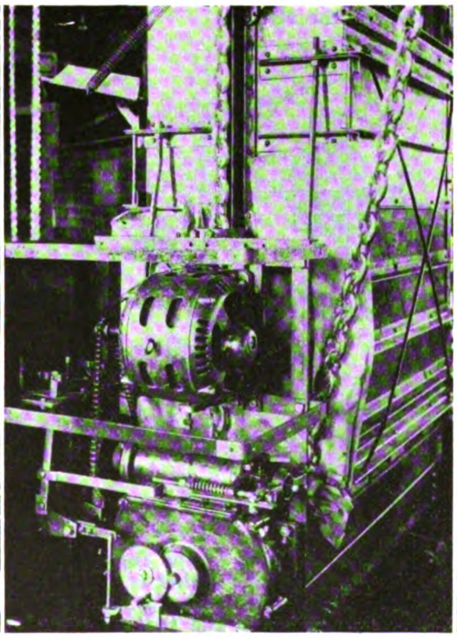
This drive is subjected to a terrific jerk when the motor is started. As the load cycle is continued the motor slows down under the heavy load until the current is automatically cut off before the motor comes to a dead stop. This chain drive operates a baler.

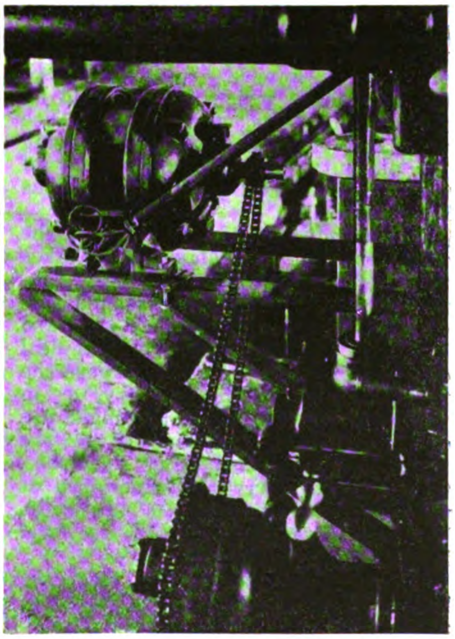
The superior results obtained with the roller chains are due to the fact that they run very satisfactorily under adverse conditions. Dust, dirt, and poor lubrication are not especially harmful. We are so thoroughly sold on roller chain that we are now using it in our factory to drive machines. In this work it is giving excellent service, runs quietly, and has a long life.

A. C. BURROWS.
Chief Engineer,
Economy Baler Company,
Ann Arbor, Mich.

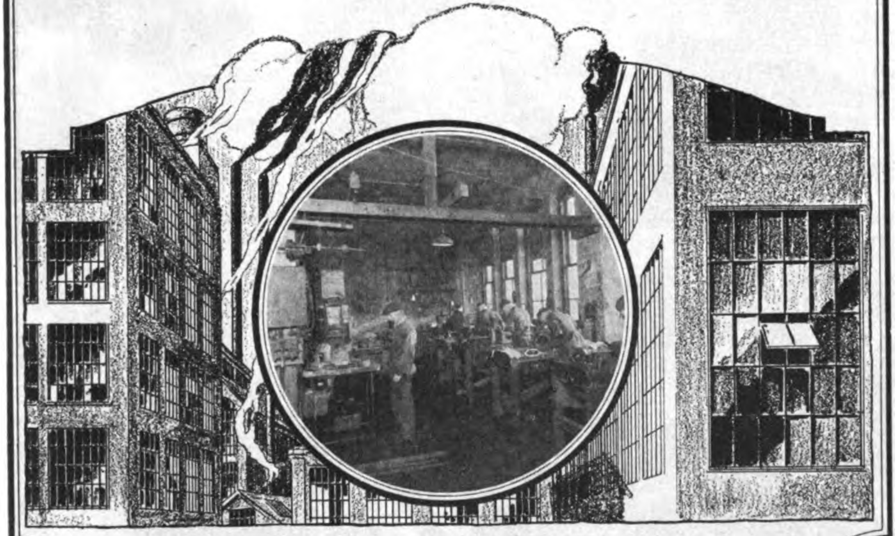
Three applications of roller chain. On the left is the drive on a 42-in. boring mill. The motor used is 7½ hp., 1,800 r.p.m. In the center illustration the roller chain connects a 5-hp. motor with a 50-ton, waste-paper press. On the right is a 5-hp. motor driving a boring and drilling machine through a roller chain.







In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

The Drying Through of Baking Insulating Varnishes

I HAVE read an article appearing in the July issue of INDUSTRIAL ENGINEER entitled, "When Analyzing Coil Insulation Troubles," by H. L. Hazeltine, Engineer of Insulation, The Sterling Varnish Company, Pittsburgh, Pa.

I feel that it is unfair for manufacturers of insulating varnishes to make such statements as appear in the article, under the sub-heading of Baking Varnishes, page 333. Under this heading the writer states:

"Some materials have been sold on the claim that they will dry from the inside out and that, therefore, drying can be obtained all the way through. These materials have not been a success as it has been definitely proved that they will also form a skin, over the outside surface, and when such a skin is formed the oxidation of the varnish base is stopped. Rather than select a material which must be sold by false claims it is much wiser to see what can be done towards remedying the difficulty by a proper method of treating the coils after the varnish has been applied."

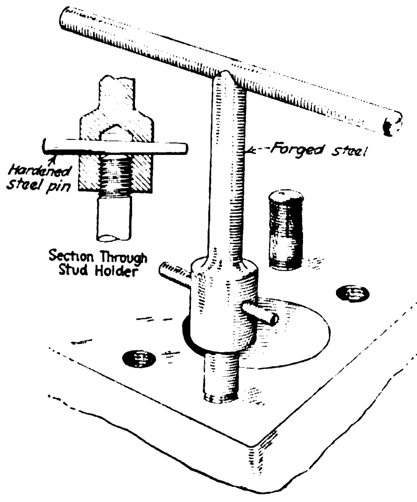
In our advertisements we make the statement that "Chinalak Black—bakes through." The writer has been connected with the manufacture and sale of insulating varnishes since 1897 and has tried to keep abreast of technical developments in the art. We were the first company in this country, or in the world for that matter, to make use of China wood oil exclusively in the manufacture of insulating varnishes. Our products carry the experience of many years, are carefully made and the best raw materials obtainable are used in their manufacture.

My chief objection to this reference is the positive statement, without submission of proof, that certain things cannot be done, followed with the intimation that anyone making such claims is selling his product under false pretenses. The writer of the article may say that he does not refer particularly to our product, but so far as I know our company only, has come out and made the positive statement that we supply a varnish that "dries through," and we stand ready to prove this to anyone who is legitimately interested.

President, JOHN C. DOLPH.
John C. Dolph Company,
Newark, N. J.

Simple Tool for Screwing in or Removing Stud Bolts

WHILE various types of stud tools are in use, these invariably require some form of separate threaded block and a loose wrench for driving or removing the stud.



The tool is made in the form of a T-wrench. In the socket is a taper pin which serves to keep the stud from jamming in the tool when it is being tightened or loosened.

A simple tool which is designed to accomplish the separate operations of screwing in or removing a stud bolt, is shown in the accompanying illustration. As may be seen this tool is made up as a T-wrench which is threaded to agree with the stud. At the bottom of the threaded opening is a driving taper pin, the purpose of which is to hold the stud from screwing too tight in the socket. By driving this taper pin in solid with the hammer when the stud is screwed up to it the stud bolt is held firmly and can be screwed in or out of place without loosening. The stud is readily released so that it may be screwed out of the T-wrench by a single blow of the hammer on the small end of the taper pin.

Washington, D. C. G. A. LUERS.

Four-Speed Motor Changed to Single Speed and Different Voltage

A LARGE manufacturing company had a 10-hp., 220-volt, three-phase, 60-cycle, four-speed (600-900-1,200-1,800 r.p.m.) motor that was not being used. When a call came in for a 10-hp., 440-volt, 900-r.p.m. motor it was decided to investigate the four-speed motor and determine whether the 900-r.p.m. winding could be reconnected for 440 volts.

Four-speed motors have two separate windings, each winding giving two speeds; that is, one winding is arranged to develop 900 and 1,800 r.p.m., with four and eight poles and the other winding gives 600 and 1,200 r.p.m., with six and twelve poles.

Investigating the bottom or four- and eight-pole winding, it was found that the four-pole (salient) winding was connected series-delta, seven leads being brought out as in diagram (A). The coil pitch was 1-and-10, which is 50 per cent pitch for four poles and seventy-two slots. The winding was found to be arranged in twelve groups with six coils in series per group and four groups per phase. The winding consisted of eight turns of two No. 15 silk-and-enameled wires in parallel. Notice that in diagram (A) the arrows on adjacent pole-phase groups point in different directions. For the eight-pole winding the leads are changed as shown in (B), which gives an eight-pole (consequent pole) winding; or, in other words, four pole-phase groups develop eight poles. The connection is changed to two-parallel star on the eight-pole winding and arrows on all pole-phase groups point the same direction.

Since it was desired to operate this motor on a 440-volt line, and at 900 r.p.m. it meant that the motor must be reconnected series-star for 440 volts, and still maintain the eight-pole (consequent pole) winding. From a study of the small diagram under (B) it will be seen that by opening connection (14) between groups (12) and (3), and also jumper (1) between groups (6) and (1), and then connecting the end of group (6) to the beginning of group (3) and bringing out a lead from the

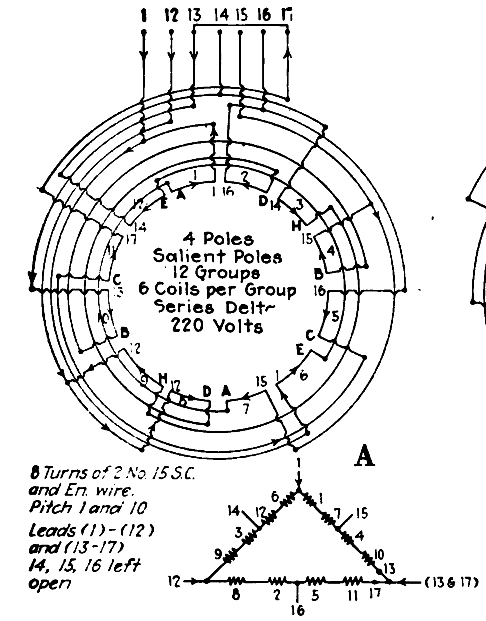
beginning of group (12) and calling the end of group (9) the star connection, we will put all four pole-phase groups of one phase in series as is shown in the small diagram under (C) and also maintain the proper polarity of each pole-phase group. The same thing can be done to the other phases. This will give a series-star, eight consequent-pole winding for 440 volts.

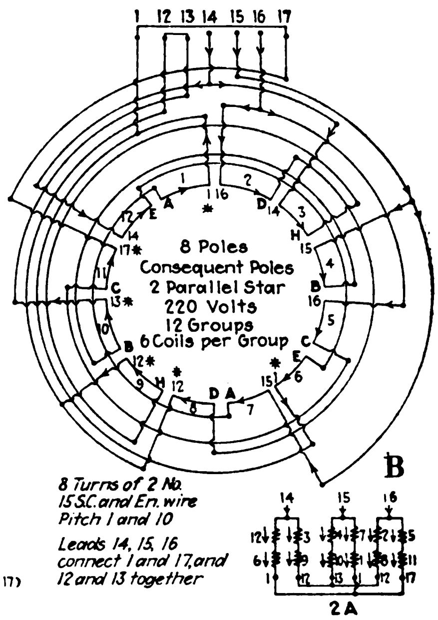
The resulting series-star connection is shown in (C). The groups are numbered the same as in (B) and the heavy figures show where the lead jumper has been opened and changed to a group jumper. Also leads (14), (15) and (16) are still attached to the beginning of groups (12), (4), and (2) as in diagram (B). One end of lead (12) is used as a star connection, as is also lead (1). Lead (17) is not changed. With this connection six leads can be brought out and the star connection made outside, or the star connection can be made inside the motor and only three line leads brought out. When using only one winding be sure that the other winding is open-circuited; otherwise the eight-pole winding will set up a current in the six- and twelve-pole winding by transformer action.

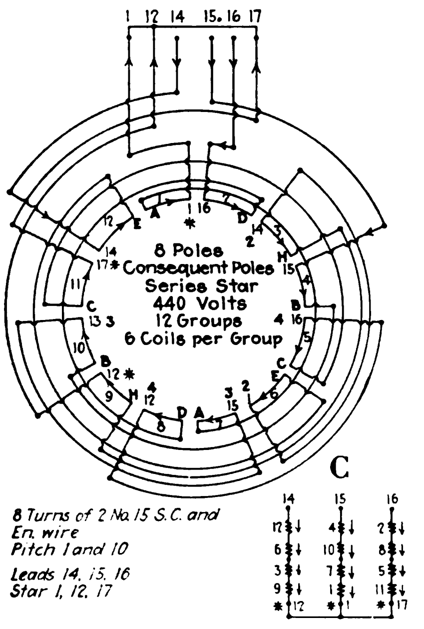
The motor was reconnected as shown in diagram (C) and ran satisfactorily for a long period. When the motor finally burned out it was decided to rewind it and only put in one winding, thus doing away with the unused winding. It was rewound for a rating of 10 hp., 440 volts, three phase, 60 cycles, 900 r.p.m., and eight poles. As stated before, the four- and eight-pole windings consisted of seventy-two coils of eight turns of two No. 15 silk-covered, enameled wires per coil, pitch 1-and-10, or 100 per cent pitch for eight poles.

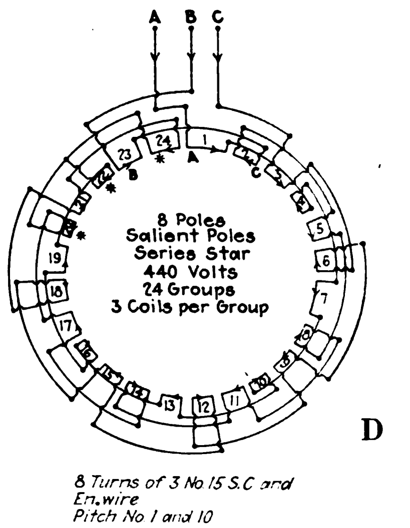
Diagram (A) shows the original 900-r.p.m. winding while (B) shows the connections for 1,800 r.p.m.

In (C) the connections are changed so as to give 900 r.p.m. at 440 volts instead of 220 volts. Later when the motor was entirely rewound, the winding and connections shown in (D) were used.









With the eight consecutive-pole, 440-volt, series-star connection, there were four groups of six coils per group or twenty-four coils in series per phase and each coil had eight turns. Then the number of turns per phase is equal to $(8 \times 24) = 192$. On rewinding the motor, it was decided to group and connect the winding in the standard manner; that is, with eight salient poles or twenty-four groups of three coils per group. Then, using eight turns of two No. 15 silk-covered and enameled wires per coil, the same as before, the number of turns per phase would be $(8 \times 3 \times 8) = 192$, or the same as with the consequent-pole grouping.

Since the coils of the original four- and eight-pole winding were wound with eight turns of two No. 15 wires in parallel and since there were two coil sides per slot, this winding had a total of $(2 \times 8 \times 2) = 32$ wires per slot. The coils of the original six- and twelve-pole winding were wound with ten turns of two No. 15 wires in parallel and since there were two coil sides per slot, this winding had a total of $(2 \times 10 \times 2) = 40$ wires per slot. Hence each slot contained four coil sides with $(32+40) = 72$ No. 15 wires.

With the single winding there would be only $(2 \times 8 \times 2) = 32$ wires per slot; therefore we can use eight turns of three No. 15 silk-covered, enameled wires per slot. This would make a cooler running motor.

The final rewinding data was eight turns of three No. 15 silk-covered, enameled wires in parallel, pitch 1-and-10, connected series-star, as in (D).

Detroit, Mich. A. C. Roe.

Wire Solder May Be Used as French Curve In Emergency

Recently while making a drawing I found it necessary to use a spline or adjustable curve. As I did not have one at the moment, it was necessary to use the next best thing, a piece of ordinary wire solder. It served well and now finds a place in my drawer, with the other drawing instruments.

I find that it is indispensable for drawing large and odd-shaped curves and it often fills a want where a French curve will not fit. It is perfectly flexible, yet holds its shape when once formed. Further, the ruling pen easily follows the curve and because of the circular cross section of the wire, the ink will not spread under the curve and thus spoil a drawing.

Hard solder is preferable for this purpose as it holds its shape better than the soft variety and is less likely to kink while the curve is being formed. When using a piece of wire solder for this purpose, form the wire along the pencil curve and place two or more paper weights or other small objects on the solder to prevent movement. Then rule the curve between the weights. When the ink dries move the weights and complete the ruling of the curve.

Oakland, Calif. S. H. Samuels.

Details of Paper Mill Drives

(Continued from page 367)

large size of the motors (600 hp. up) belt drive is out of the question on account of space. Direct drive in this department is the only type of drive feasible.

On elevator legs of the bucket type, the motor is sometimes direct connected to a shaft in the top of the leg, to which is keyed the sprocket which carries the chain. As the space at the head of the leg is usually limited, direct drive is the most suitable type.

Direct drive is also used on agitators, or mixing tanks. Since these tanks are usually open at the top, the motor is likely to be flooded at any time and belts and other types of drive are inconvenient. The drive is usually horizontal, the shaft terminating in a bevel gear at the center of the tank. Reduction gears are often used in this capacity, but since they are usually part of the agitator equipment, the drive may be called the equivalent of a direct drive.

There are several types of gear drive. Those most commonly used are the spur, bevel, worm and herring-bone. The latter type of reduction gear is the best, as it is practically noiseless in operation and can be run at extremely high speeds—5,000 r.p.m. and over.

Where paper machines are of the sectional types, such as the Harland or General Electric, reduction gears are used between the motor and the particular section being driven. While the gear occupies nearly as much space as the motor, the motor frame size is much smaller, owing to the higher speed, since the higher the speed of a motor the smaller the frame size for a given horse-power output.

Bevel gears are advantageous where the drive is changed in direction, say horizontal to vertical drive, as on the agitators, mentioned before.

Back-geared motors are usually of the spur type, and have an advantage over most types of drives where the speed of the driven equipment is low and the required horsepower is small. An example of this kind is seen in a save-all, which is a revolving wire cylinder provided with slats to gather the stock from the water going to the sewer. The speed of the cylinder is usually not more than 40 to 50 r.p.m., and the required horsepower is from 3 to 5. With motors of this size at speeds of 720 to 1,200 r.p.m., the cost of the motor is low, the gears cost much less than line-shafting and belt, the unit occupies very little space and can be housed from dampness.

This type of drive is also used to some extent on elevator buckets where the heat would be ruinous to a belt, as is the case with the sulphur burner.

Worm-gear drive is probably used most in pulp and paper mills in connection with freight and passenger elevators and is the only practical drive for this service.

Applications Suitable for Chain and Belt Drive

The chain drive has one or two advantages over the belt drive, in that a much shorter drive can be

Table XVII—Drive Data of Steam Plant

Duty	No. of Motors	Type	Hp. Rating	R. P. M.	Drive
Refuse conveyor	1	S. C.	10	600	Belt
Stoker drive	1	S. C.	1	1,200	Belt
Blower	1	S. C.	75	1,200	Direct
Coal elevator	1	S. C.	7.5	720	Gear
Coal conveyor	1	S. C.	7.5	1,200	Belt
Coal crusher	1	S. C.	30	720	Belt
Ash conveyor	1	S. C.	10	1,200	Belt
Total	7		141		

All of the above motors are three-phase, 550-volt, squirrel-cage (S.C.) motors.

Table XVIII—Data on the Water Supply Drives

Duty	No. of Motors	Type	Hp. Rating	R. P. M.	Drive
Low-head pumps	3	S. C.	75	1,200	Direct
High-head pumps	3*	S. C.	175	1,160	Direct
Total	6		750		

*One of these motors is a spare. Never more than two running at a time.
All of the above motors are three-phase, 550-volt, squirrel-cage (S.C.) motors.

Table XIX—Data on the Miscellaneous Drives

Duty	No. of Motors	Type	Hp. Rating	R. P. M.	Drive
Synchronous condenser	1	Sync.	495	600	....
Portable air compressor	1	S. C.	5	1,800	Belt
Air compressor	1	S. C.	15	860	Belt
Machine shop	1	S. C.	20	600	Belt
Concrete mixer	1	S. C.	10	1,200	Gear
Total	5		545		

All of the above motors are three phase, 550 volt.
The actual load taken by the condenser is 50 hp., so that the actual load of the miscellaneous motors is 100 hp., with the average at 70 hp.

Table XX—Summary of Lighting Load

Department	Kw. Load
Ground-wood mill	2.75
Wood handling, sulphite mill	4.07
Steam plant	4.95
Yard	12.00
Sulphite mill	12.87
Bleach plant	2.20
Paper mill	34.48
Stables	1.44
Water supply	1.35
	76.11

Table XXI—Summary of Heating Load

No. of Heaters	Duty	Kw. Rating	Voltage
	WINTER LOAD		
9	Low-head pump house	37.500	550
1	Weigher's lab	11.000	550
1	Weigher's heater	2.500	550
1	Scale heater	1.000	110
1	Elevator penthouse	2.500	550
1	Lunch room	2.000	110
1	Chemical lab	4.125	550
1	Sad-iron heater	0.825	110
1	Sad-iron heater	1.650	110
1	Motor baking oven	2.500	550
3	Sub-station heaters	15.000	550
21		80.6	
	SUMMER LOAD		
1	Weigher's lab	11.000	550
1	Chemical lab	4.125	550
1	Sad-iron heater	0.825	110
1	Sad-iron heater	1.650	110
1	Motor baking oven	2.500	550
5		20.100	

Average yearly load—66.9 kw.

used and there is no slippage. In other words, it is a positive drive. It also causes less strain on the motor bearings. The disadvantages of chain drive are its cost and its speed limit, as it cannot be used where the speed is high. One thousand feet per min. is the limit for roller chain and 700 feet per min. for block chain. It is capable of transmitting greater power at slow speeds than the proportionate size of belt.

Where the driven machinery is exposed to the weather, as is the case with slasher saws and conveyors, chain drive has an advantage, not only because it is less affected by dampness, but due to the fact that the drive can be shortened; in fact, the driving and driven sprockets can be placed as close together as the size of the motor will allow.

Chain drive is also the proper type to use with conveyors since, as stated before, the drive is positive; with belts, the slippage and running off cause delays and loss of production.

The main advantage of the various kinds of belt drive, is the first cost. Where the belt is not subject to injury, through the action of chemicals or moisture, it may last indefinitely, providing the load it is driving is within its range. By far the greater number of drives in a pulp and paper mill are belt, owing mainly to the first cost. The main cost of the upkeep is probably labor, but since a mill has to have a certain number of millwrights, who are usually monthly men, the cost per unit is small.

In a paper mill, the greatest number of belts from one drive is the constant line. As all the units of the constant line are dependent on one another, it is the practice to put all the machines on one large motor, and thus group the drives. The number of machines in the group runs from twelve to fifteen, averaging in rating from 2 to 35 hp., on a 40-ton book machine. The list comprises plunger, centrifugal and suction pumps, air compressor, stock thickeners, agitators, screens and the shaker for the wire section or couch. Link leather belt on flanged pulleys is used for the super-calenders.

In a mill the size of this one the methods of obtaining the light and heat are of interest. The lights are supplied from two sets of 550-to-110-volt transformers. The sulphite and ground-wood mills are fed from three 15-kva. transformers connected in parallel across one phase; the paper mill is fed from two 30-kva. transformers in parallel across another phase. Two-wire, 110-volt lighting is used throughout, and while this method might be considered expensive, owing to dampness and acid fumes, it has been found economical, as no trouble has been experienced. The paper mill and ground-wood mill are equipped with R. L. M. dome reflectors throughout, except in the sulphite mill where the lighting is of such a nature that the use of reflectors is not permissible. The yard lighting consists of eighteen 500-watt units on wooden poles and three 1,000-watt floor lights which can be moved. The latter are used on the storage pile. Table XX shows the lighting load of the various departments. The yearly lighting load is 450,000 kw.-hr.

In certain parts of the mill, it was found that electric heating was more economical than any other method; for instance, in the low-head pumping station, which is one-third of a mile distant from the steam plant. It was also more dependable in heating the scales and in the various drying ovens. The load varies considerably. For the seven months dating from Oct. 25th to May 15th, the average load is 80.6 kw., while for the remaining five months, the average load is 20.1 kw. The average yearly load is 66.9 kw. or 89.6 horsepower. Table XXI shows the winter and summer heating loads.

Testing Armatures During Rewinding

(Continued from page 377)

a very low reading and also that a poor contact will give a high reading. When making tests on hand-wound armatures there are a number of causes that contribute to high and low readings. When testing an armature that has the commutator leads connected but not soldered, if the leads fit easily in the neck, consistent readings may not be obtained because poor contact may increase the resistance of the coil under test. Hence a series of high and low or irregular readings will be the result. Other things that may cause a variation in the readings are a large number of turns per coil, the use of small-sized wire in the coil, or one or two turns may have been left out of the coil. Sometimes a cord or tape band put on tightly over the leads just back of the commutator will cause the leads to make better contact in the neck and give more consistent readings in the bar-to-bar test. When a low reading is obtained in the bar-to-bar test and if there is any doubt about it being a short, use the growler.

Controlling Industrial Lubrication

(Continued from page 372)

is submitted for analysis together with a statement of the trouble.

It is very seldom that any trouble is found with the quality of the lubricant. Its purchase from a reliable company which knows that it is being carefully checked as to quality precludes any substitution of an inferior grade. This has only happened once in our experience. Needless to say, we make no further purchases from the concern in question. Most of the trouble with motor cars is due to not changing the oil in accordance with instructions, or to carelessness on the part of the driver in using his choke so frequently that he gets an abnormal amount of raw gasoline in the crankcase. In the case of machinery it is generally due to some changed condition in the operation of the machine which has not come to the notice of the *Engineering Department.*

The subject of laboratory control for lubrication problems is of too great length to be considered here. It is possible, however, for the average shop man to do something along this line without the assistance of a chemist. The specific gravity of the oil used may be determined by the ordinary hydrometer and the amount of dilution of the oil by foreign matter can be determined by comparing the specific gravity with that of a sample of fresh oil. Oil from a bearing which has been giving trouble can be warmed up to decrease its viscosity and filtered through several layers of cheese cloth. This will filter out any foreign matter in the oil, the nature of which can be generally determined by inspection as to whether it is metal from the bearing or shaft or whether it is foreign material drawn into the bearing during the operation of the machine. In complicated cases of bearing trouble it is, of course, necessary to have available the services of a chemist and laboratory. The rough tests outlined, however, will take care of a large number of cases of trouble which may occur.

Insulating Varnish Tests

(*Continued from page 385*)

stands up in actual service. No tests are of any particular value unless the results are backed by actual application to the manufactured product. Hence, it will be noted that in the interpretation of test results we have included all of the features interesting to the user of liquid insulators: namely, tests for physical and electrical characteristics, percentage of base, the cost per gallon and the endurance of the material under operating conditions in actual service.

So far the selection of varnishes has been based almost entirely upon the results of tests made either in the shop or in the laboratory upon small quantities of the materials in question. A selection so based is, however, unreliable when too much importance is placed upon these results because the results obtained by test even when conducted by the best scientific practice can seldom be duplicated. Take for example the test for dielectric strength; the best results obtained show a variation of 25 per cent when measured on the same sample. When specimens have been prepared on different days or by different operators these variations will be considerably greater. The same thing holds true in other tests. Take the one for drying time, for example. One laboratory has found that a certain varnish dries in 45 min.; another finds that the same material requires 55 hr., when apparently prepared in exactly the same way and baked under the same conditions.

Specifications for Insulating Varnishes

In many shops, particularly the large ones, it has been the practice to draw specifications for insulating varnishes, based upon elaborate laboratory tests to determine the characteristics of a varnish. The object of such specifications is to obtain a list of materials of different manufacture that will be suited to the work in hand and then allow the purchasing agent to select from this list that one which can be obtained for the lowest price. When these specifications contain a test for the percentage of base and allowance is made in the report to the purchasing department this practice is not so bad. It is, however, generally found that either almost any material will fit these specifications or else no material at all will fit them. The variations in the drying period described above illustrate this characteristic very clearly. In either case the specifications are of little or no value, so far as practical results are concerned.

The writer was shown a specification of this kind a short time ago. It described in great detail the tests to be made and the physical requirements of the varnish. When bids were asked the prices were found to range from $3.65 per gallon to $0.65 per gallon, and each bid contained a guarantee that the particular product quoted would fit the specification. Obviously when such a variation in price is permissible something is wrong.

Ideal Specifications Have Not Been Written

Steel has been purchased for many years by means of specification and the results appear to be entirely satisfactory. Perhaps, then, if varnish specifications were made out in a similar form equally satisfactory results would be obtained. We find, however, that in the specification for steel the chemical analysis is given. Perhaps if the raw materials entering into the composition of varnish were stated the problem would be solved. Unfortunately, however, the characteristics of these raw materials are often completely changed by the process of combining them so that the result has no semblance to the original substances. Any variation in the process changes the results; hence a description of the process should also be included in order to have the specifications complete and adequate.

Suppose this were done and the ideal specification written so as to include the substances used, the way in which they are to be combined and the physical tests which the finished product must pass; what assurance would the consumer have that his specification was being followed? In a properly constructed varnish the elements are so chemically combined that they defy an analysis even approaching accuracy. Hence, the customer would be unable to check up his source of supply unless he had an inspector present during manufacture and would soon find himself in the same position he is in now.

Since tests and specifications are unreliable, what then should be the true basis for varnish selection? Instead of attempting to approve as many different types of varnish and of as many different manufacturers as possible it would appear that the first step should be to select the supplier of these materials. This choice must necessarily be based upon confidence. Pick out those suppliers whose reputation and whose products have stood the test of time. Be sure that they understand the manufacture of insulating varnish. Be sure that they also understand the application of these materials to electrical work. In this way you will assure yourself of obtaining good materials and at the same time constructive ideas should trouble arise.

Then make sure that these different suppliers are furnishing you with the same grade of material and use your tests as a means of checking and of indicating to you the suitability of their products. Next try the materials offered in service and in production.

Selection of Proper Insulating Varnish Important

Insulating varnish is too important a factor to be overlooked either in the manufacture of a new machine or in the repair of an old one. Otherwise good results can be spoiled by the use of a poor or improper insulator. There is quite a similarity between the purchase and use of insulating varnishes and the purchase and use of clothing. One does not wish to wear a dress suit when greasing his automobile nor does he wish to wear overalls at the theater, but he does insist that the type of suit be adapted to his particular occupation and that it must be substantially made so as to give long wear. The difference in cost between overalls and a dress suit is considerable, and yet you cannot compare their value one with the other because they are used for different occupations, in which the requirements are different.

This holds true of insulating varnish. You must first determine what service your product is to perform and having determined upon the type of insulator, then you want to secure the best of this particular type. The reputable manufacturers of insulating varnish have no mysteries about their business and there is no reason why the electrical repair man should not have as thorough a knowledge of insulating varnishes as he has of any other product used in making electrical machines.

Achievements of Benj. G. Lamme

(*Continued from page 359*)

No. 633,856—Distributed winding for electrical machines, Feb. 6, 1899.
No. 633,857—Dynamo-electric generator, April 14, 1899.
No. 633,858—Field-magnet coil for electrical machines, June 14, 1899.
No. 633,972—Current collector for electrical machines, June 5, 1899.
No. 644,864—Electromotive-force regulation, Oct. 6, 1898.
No. 644,865—System of electrical distribution, June 14, 1899.
No. 646,092—Dynamo-electric machine, June 30, 1899.
No. 660,907—Single-phase a.c. generator, May 24, 1899.
No. 660,908—Variable-speed electric motor, June 5, 1899.
No. 660,909—Electric motor, Sept. 14, 1899.
No. 660,910—System of electrical distribution, April 14, 1900.
No. 660,911—Alternating-current induction motor, April 14, 1900.
No. 668,194—Rotary field-magnet for electrical machines, July 14, 1900.
No. 673,911—Polyphase, a.c. motor, Jan. 30, 1899.
No. 673,912—System of electrical distribution, July 14, 1900.
No. 673,913—System of electrical distribution, July 14, 1900.
No. 680,792—Alternating-current induction motor, May 24, 1899.
No. 680,793—Dynamo-electric generator, June 28, 1900.
No. 682,942—Rotary transformer, Jan. 28, 1897.
No. 682,943—Method of changing frequency of alternating currents, July 24, 1897.
No. 688,317—Winding for electrical machines, April 17, 1901.
No. 688,318—Winding for electrical machines, April 30, 1901.
No. 692,021—Regulation of rotary converter electromotive force, April 17, 1901.
No. 692,022—Winding for electrical machines, June 26, 1901.
No. 695,937—Alternating electric current generating and distributing system, July 31, 1896.
No. 695,938—Alternating-current motor, July 14, 1900.
No. 702,657—Speed regulating means for electric motors, April 30, 1901.
No. 702,658—Dynamo-electric generator, Sept. 24, 1901.
No. 710,158—System of electrical distribution, Oct. 14, 1901.
No. 710,363—Method of starting rotary converters. Original application filed Oct. 14, 1901. Divided and this application filed Feb. 1, 1902.
No. 731,466—Lighting apparatus for railway vehicles, Sept. 29, 1902.
No. 731,467—Electric lighting apparatus, Sept. 29, 1902.
No. 740,147—Electromotive-force regulator, Oct. 2, 1902.
No. 758,667—Single-phase, a.c. power system, Dec. 26, 1901.
No. 758,668—Single-phase, a.c. motor. Application filed Oct. 31, 1902, renewed Sept. 24, 1903.
No. 758,669—Brush holder for electrical machines, Sept. 16, 1903.
No. 759,183—Method of utilizing single-phase, a.c. energy. Original application filed Dec. 26, 1901. Divided and this application filed July 16, 1902.
No. 765,185—Controlling apparatus for electrically-propelled railway vehicles, Sept. 29, 1902.
No. 775,334—Alternating-current electric motor, Feb. 27, 1904.
No. 780,045—Single-phase, a.c. motor, May 3, 1904.
No. 780,046—Armature winding for electric motors, May 3, 1904.
No. 780,047—Electric motor, June 30, 1904.
No. 794,362—Electric motor, May 3, 1904.
No. 794,363—Electric motor and controlling means therefor, Jan. 3, 1905.
No. 807,943—Regulating means for system of electrical distribution, Feb. 1, 1905.
No. 811,231—Alternating-current motor, June 30, 1904.
No. 811,644—Single-phase, a.c. motor, Feb. 27, 1904.
No. 814,380—System for variable-speed operation of a.c. motors, Oct. 8, 1904.
No. 819,770—System of electrical distribution, June 30, 1904.
No. 821,044—Induction motor, Feb. 27, 1904.
No. 822,376—System of applying a.c. electrical energy, Sept. 22, 1904.
No. 834,582—Controlling device, Jan. 3, 1905.
No. 838,034—Electrical machine, Feb. 21, 1905.
No. 839,935—Phase-adjusting means for a.c. motors, Feb. 6, 1905.
No. 839,936—Phase-adjusting apparatus, Feb. 6, 1905.
No. 839,937—Method of regulating the speed of electric motors, Feb. 6, 1905.
No. 840,001—Method of regulating a.c. motors, Feb. 6, 1905.
No. 854,897—Armature for dynamo-electric machines, Sept. 20, 1906.
No. 856,477—Alternating-current motor, Feb. 27, 1904.
No. 885,163—Armature winding for high-speed, dynamo-electric machines, June 2, 1905.
No. 888,514—Armature winding for electrical machines, Aug. 17, 1904.
No. 888,912—Method of operating and system of control for electrical generators, Aug. 2, 1906.
No. 896,220—Electric locomotive, Jan. 5, 1907.
No. 900,289—System of control for electric motors, Dec. 4, 1905.
No. 900,555—Controlling system for electric motors, Original application filed Dec. 4, 1905. Divided and this application filed Feb. 24, 1908.
No. 905,889—Coil support for dynamo-electric machinery, June 28, 1905.
No. 911,018—Electrical apparatus, May 6, 1907.
No. 913,017—Dynamo-electric machine. Application filed Aug. 2, 1906. Renewed July 3, 1908.
No. 923,666—Protective device for commutator-type, a.c. motors, June 30, 1904.
No. 923,667—Winding for electrical machines, June 2, 1905.
No. 924,799—Electrical equalizing system, Sept. 3, 1907.
No. 925,355—Method of, and means for, operating dynamo-electric machines, Aug. 2, 1906.
No. 925,356—Electrical load-equalizing system. Original application filed Sept. 3, 1907. Divided and this application filed Nov. 6, 1908.
No. 925,357—Electrical equalizer system. Original application filed Sept. 3, 1907. Divided and this application filed Nov. 30, 1908.
No. 931,130—Commutator for dynamo-electric machines, Oct. 7, 1908.
No. 933,765—Winding for armatures of dynamo-electric machines, Nov. 3, 1906.
No. 940,698—Dynamo-electric machine, Sept. 13, 1905.
No. 947,389—Dynamo-electric machine, June 2, 1905.
No. 964,658—Method of operating electric motors. Application filed May 3, 1904. Renewed Oct. 20, 1908.
No. 964,659—Means for operating and controlling single-phase, a.c. motors. Application filed May 3, 1904. Renewed May 19, 1909.
No. 964,793—Method of operating and controlling single-phase, a.c. motors. Original application filed May 3, 1904. Divided and this application filed July 9, 1906.
No. 964,794—System of control for electric motors. Original application filed May 3, 1904. Divided and this application filed April 5, 1907.
No. 977,640—System of operation for dynamo-electric machines, March 15, 1906.
No. 977,641—System for the operation of dynamo-electric machines, March 15, 1906.
No. 978,038—System of regenerative control for electric motors. Original application filed March 15, 1906. Divided and this application filed Nov. 8, 1907. Renewed May 20, 1910.
No. 1,007,457—Coil support for dynamo-electric machinery, April 13, 1905.
No. 1,018,571—Dynamo-electric machine, April 10, 1908.
No. 1,031,009—Dynamo-electric machine, Sept. 6, 1910.
No. 1,066,507—System of control for electric motors, Sept. 26, 1910.
No. 1,070,492—Winding for dynamo-electric machines, Jan. 26, 1910.
No. 1,074,125—Method of operating induction motors, July 6, 1908.
No. 1,082,532—Dynamo-electric machine, Feb. 21, 1911.
No. 1,095,331—Field-magnet winding for dynamo-electric machines, Jan. 26, 1910.
No. 1,123,321—Method of operating polyphase induction motors, July 6, 1908.
No. 1,138,672—Dynamo-electric machine, Sept. 10, 1909.
No. 1,138,673—Switching device, Oct. 31, 1913.
No. 1,150,043—Dynamo-electric machine, Jan. 26, 1910.
No. 1,151,804—Electric motor, Jan. 26, 1910.
No. 1,158,511—Polyphase synchronous motor, Jan. 7, 1911.
No. 1,158,512—Two-speed induction motor winding, Jan. 24, 1914.
No. 1,186,804—Equalizing means for dynamo-electric machines, July 24, 1912.
No. 1,189,703—Alternating-current motor, Jan. 26, 1910.
No. 1,241,523—Control system, Feb. 25, 1914.
No. 1,243,307—System of distribution and control, March 23, 1914.
No. 1,243,430—System of distribution and control, Dec. 26, 1913.
No. 1,244,509—Dynamo-electric machine, Aug. 22, 1913.
No. 1,244,510—Universal motor, July 30, 1914.
No. 1,244,511—Universal motor, Aug. 7, 1914.
No. 1,246,617—System of distribution and control, March 23, 1914.
No. 1,275,945—Switching device, Aug. 2, 1913.
No. 1,295,906—Speed control for induction motors. Original filed Jan. 5, 1915. Divided and this application filed Oct. 21, 1916.
No. 1,300,742—System of control, Jan. 5, 1915.
No. 1,305,126—Switchboard apparatus, April 29, 1915.
No. 1,316,798—Dynamo-electric machine, May 2, 1917.
No. 1,318,775—Speed-controlling system for induction motors, Feb. 19, 1914.
No. 1,333,664—Speed control for induction motors, Oct. 21, 1916.
No. 1,336,566—Speed-control system for induction motors, May 2, 1918.
No. 1,387,496—Speed control for induction motors, Oct. 21, 1916.
No. 1,390,624—System of electrical ship propulsion, June 29, 1918.
No. 1,392,182—Means for preventing commutator flashing, June 17, 1918. Renewed July 9, 1921.
No. 1,416,038—Driving system for gyroscopic stabilizers, Feb. 19, 1917.

Changes in Distribution System

(*Continued from page 380*)

As shown in Fig. 2, the trough system of wiring was used, inasmuch as it is the most practical for this kind of an installation. All of the wiring is concealed and is thus fire proof and danger proof, but is readily accessible when occasion arises. The trough was made of No. 14 galvanized iron with sectional covers which are fastened on with machine screws.

In the underground work, fiber conduit was used throughout except in the case of short runs for service to buildings. Digging of the trenches was done by the inmates of the institution as well as could have been done by paid help. In laying the duct a 4-in. concrete base was first laid using a 4:3:1 mix. The ducts were, for the most part, laid four wide with 1 in. between ducts and 1 in. of concrete over the ducts. A 3-in. slab was placed on the top layer of ducts. Throughout the installation all of the equipment and manholes were so laid out that it is impossible for the inmates to interfere with them in any way. All manholes in which any transformers or other equipment is installed, are

7 ft. long, 5 ft. wide and 6 ft. high; all others are 4 ft. square by 5 ft. high. In Fig. 3 is shown a diagram giving the location of the buildings and high- and low-tension feeders.

All of the manholes have two 8-in. x 4-in. steel I-beams buried in the top slab, 1 in. below the manhole ring, and are reinforced with ¾-in. and ⅜-in. round steel. The walls are 8 in. thick with a 12-in. top and a 10-in. bottom. All of the manholes have sewer connections and are equipped with pressed-steel cable racks and hooks. At suitable locations 2,400-volt subway junction boxes of the disconnecting type are used for testing purposes. All joints are wiped with lead—no stuffing-type joints are used anywhere.

All underground transformers are protected with oil cutouts on the primary side, with a secondary distribution subway box on the secondary side. As a precaution, a test was taken on all of the oil before it was placed in the transformers, as it had been stored outside during the winter, but moisture was found in only one drum. All neutrals are grounded in the manholes as well as at the building entrance. Where three-phase power was needed as well as single phase, the transformers were connected open-delta.

Since this new installation has been completed, the maintenance on all electrical work has been cut somewhat over 50 per cent, and the power bill has been considerably lowered owing to better voltage regulation, making the use of smaller motors possible, and the clearing up of many badly grounded circuits.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Charles Bond Company, 617-619 Arch Street, Philadelphia, Pa.—Booklet S describes the Bond litestrong pressed steel shaft hanger and the junior pressed steel counter shaft hanger and counter shaft bearings, together with dimensions and prices.

The Nichols-Linchern Company, 7960 Loraine Avenue, Cleveland, Ohio—A series of light-weight universal signal lights which are made with a cast aluminum body and carry a 4-in. corning lens in either ruby, green, yellow or clear, are described. These are used for building exits, tower-house signals, train signals, steel mill yards or in any other place where it is necessary for danger, caution or clear signal to be placed. These lights are made in 1-way or 5-way type or may be used in a light-weight, large or small signal lantern. The aluminum gives light weight, resists rust, is not affected by dusty, acid or moist atmosphere and will not break under rough handling. These are made with bases for several different methods of attachment.

General Electric Company, Schenectady, N. Y.—Bulletin Y-1910 describes the new Emmett mercury vapor process in the generation of power.

The Republic Rubber Company, Youngstown, Ohio—An 8-page booklet describes the different grades of industrial fire hose. This includes hose for chemical extinguishers and chemical engines as well as double- and single-jacket, cotton, rubber-lined hose.

Lumen Bearing Company, Buffalo, New York—A 16-page booklet discusses the two following subjects: "Bushing—A Proper Driving Fit," and "Oil Grooves—Fitting Up Bearings."

Harold E. Trent, 1524 Chestnut Street, Philadelphia, Pa.—Leaflet T-A 2 describes and prices the Trent automatic control system for continuous service which not only indicates the temperature on a dial but controls the temperature by setting a lever to scale. Types 800 and 801 have a maximum range of 1,000 and 1,200 deg. F., respectively. Other types are made for a temperature from 100 up to 400 deg. This may be used for controlling electrically-heated devices, gas, steam, oil or air-heated appliances, for operating air or fuel valves independently or in conjunction, or for controlling the ratio of air and fuel valves and other uses.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—Folder 4532-A entitled: "Westinghouse Fabrics and Papers," describes and gives the principal applications, together with tables of thickness with approximate weights and size of the various forms of treated and untreated fabric, papers, sleeving, tapes, cord and thread manufactured by this company for insulating purposes.

The E. F. Hauserman Company, 1729 East Twenty-second Street, Cleveland, Ohio—Bulletins describe the Hauserman system of steel partitions, factory shelving and skylights. Sketches show the arrangement whereby each of these is erected.

The Alexander Milburn Company, 1416-1428 West Baltimore Street, Baltimore, Md.—A booklet entitled "Milburn Welding and Cutting Apparatus" describes the various types of acetylene generators and welding and cutting torches. Special oil-burning, preheating equipment is included.

The Cutter Company, Nineteenth and Hamilton Streets, Philadelphia, Pa.—The "Handbook on the U-Re-Lite" Series O, is of pocket size and devotes 96 pages to illustrations and descriptions of the various types of Cutter U-Re-Lite equipment. The size and description of each of the various sizes and some of the topics discussed are: The automatic features, overload, dalite (direct-acting time-limit) feature, time-overload curves of dalite, no-voltage feature, shunt trip feature, bell ringing feature and a discussion of the selection of the U-Re-Lite for specific service conditions.

Eldredge Electric Manufacturing Company, Springfield, Mass.—A group of small folders describes the Eldredge miniature panel ammeters and voltmeters and pocket-type ammeters, voltmeters and volt-ammeters.

L. J. Wing Manufacturing Company, 352-362 West Thirteenth Street, New York City—A folder describes the Wing "Featherweight" unit heater for heating industrial plants. These units are installed near the ceiling or roof to take the warm air from the higher levels, heat it and return it again to the working levels by mechanical means and so speed up the circulation and heating of a building.

Rockbestos Products Corporation, New Haven, Conn.—A thirty-two-page catalog, illustrated in three colors, has been prepared to serve as a reference for those interested in the use of asbestos-covered wire and cables and supplies sufficient information in regard to Rockbestos products to enable a user to make the proper selection of the wire best suited to his purpose.

Edwards and Company, Inc., One Hundred Fortieth and Exterior Streets, New York City—Catalog 9 covers the various selective signaling devices such as bells and buzzers, annunciators, push buttons, battery switches, door openers, various types of relays, burglar alarms, watchman's time detectors, fire alarms and code stations.

The Standard Electric Tool Company, Cincinnati, Ohio—A folder describes the Standard floor, tool post and bench grinders, the line of hand and screw feed electric drills and the combination portable bench stand for use with electric drills.

Diamond Saw and Stamping Works, Buffalo, N. Y.—Bulletin 18 covers the Sterling hacksaw blades for hand frames and power machines.

U. S. Light and Heat Corporation, Niagara Falls, N. Y.—Bulletin No. 789-A gives what the manufacturers believe are a dozen reasons why U. S. L. arc welders are endorsed by users.

Ajax Flexible Coupling Company, Westfield, N. Y.—An 18-page booklet describes the Ajax flexible coupling, its construction, the method of operation and gives the dimensions and prices for the various sizes as well as illustrations showing some of the applications and a partial list of users.

Crouse-Hinds Company, Syracuse, N. Y.—A folder entitled "Condulets for Concealing in Concrete" describes and dimensions condulet and fixtures of the SK series for use in permanent concrete construction. Details of a number of applications are included.

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Industrial Engineer

Devoted to the
aintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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Who Is This Fellow—The Plant Engineer?

A Question Answered by a Glimpse of His Responsibilities on the Job in Daytime, Nights and Sundays

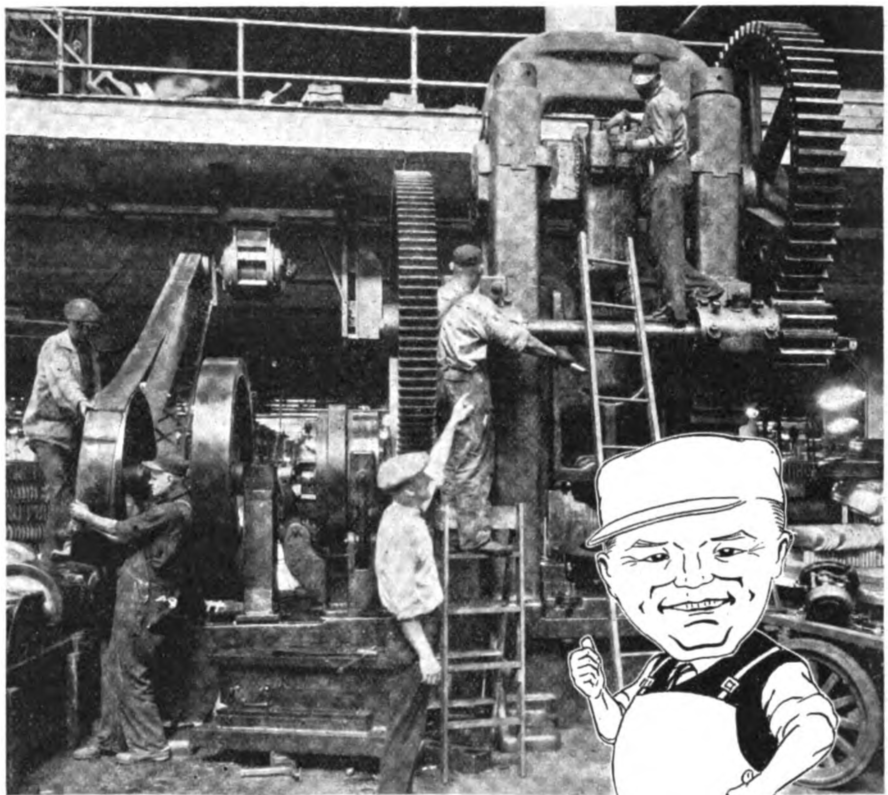
A LITTLE while ago I received an interesting letter from H. P. Meredith, General Works Engineer with the Maxwell Motor Corporation and with it came a message in rhyme that I want to pass on to you. In his letter, H. P. M. said: "In composing this I have made an effort to bring home one important point: namely, the breadth of knowledge that the successful handling of the Plant Engineer's position requires."

Who is this fellow, the Plant Engineer?
He forestalls trouble when trouble is near;
He furnishes you with light, heat and power,
And continues this service every minute and hour.

He repairs the roofs and sweeps the floors,
He relieves you of worry when worry is yours;
He oils the machinery when it groans and squeaks,
And repairs the valves when there are too many leaks.

He builds new buildings when the factory is growing,
He mows the grass when the grass needs mowing;
He turns on the lights when it's hard to see,
And unlocks the door when you've lost your key.

He places machinery where it ought to be,
He cleans the plant and keeps aisles free;
He paints the walls and ceilings, too,
And keeps interruptions to a limited few.



He opens the drains and cleans the sewers,
He places himself on the list of "Doers";
He does his duty, and does it well,
And works in the rain when it rains like Hell.

He plays the game as it should be played,
He never goes home when he should have stayed;
He orders the lumber, and nails, and screws,
And keeps his head when the "Old Man" stews.

He's diplomatic, and loyal, and true,
He displays these traits as he ought to do;
He tackles the little and the big job as one,
And never admits that "It can't be done."

He's finished his work and his day is done,
So he trudges home with the setting sun;
He's turned off the light and closed the gate,
And left his Plant to the watchman's fate.

Some day he'll "Go West," at nine or eleven,
He'll stop even then to oil the hinges of Heaven;
And as he is known as a "Doer of Things,"
They'll give him a job making Angels' Wings.

I thoroughly agree with all H. P. M. has said and I leave it with you as an inspiration from a man who gets his vision from the hill-top—not in the forest, where it's hard to see far because of the trees. On page 438 the Editors have commented on remarks made by him at a recent meeting of the Society of Industrial Engineers.

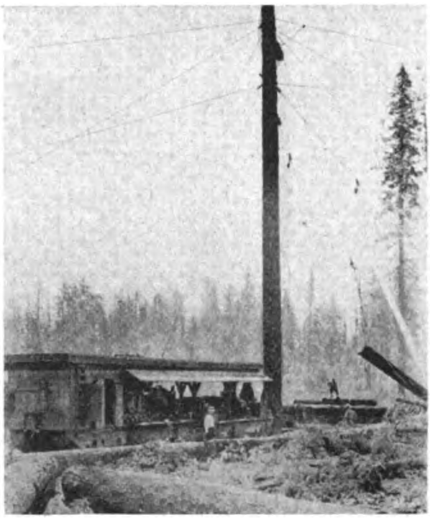
Practical Pete

A Glimpse Into the

Pacific Coast Lumber Industry

Where electrified equipment and modern methods have been applied to the gathering and loading of the logs in the woods, with a 10 per cent decrease in cost and less fire hazard, and in centrally located saw mills.

ORDINARILY logging, because of the frequent change of location and the distance from a power source, would hardly be considered as adaptable to electrification. However, about eight years ago an installation of electrified logging equipment was made by the Snoqualamie Falls Lumber Company near Seattle, Wash. Since then a number of other installations have been made on the Pacific Coast and others are contemplated. What have been considered as disadvantages of electrification have turned out to be the big advantages; for example, larger units of logging equipment can be installed, as it is not necessary to move the heavy power-generation units each time. Also, the logging units may be located without consideration of convenient water for steam generation. The decrease in the fire hazard through the absence of fire under boilers is an important consideration, as forest fires are one of the most serious hazards in lumbering. In addition, electric logging has reduced the cost about 10 per cent and also speeded up the work.



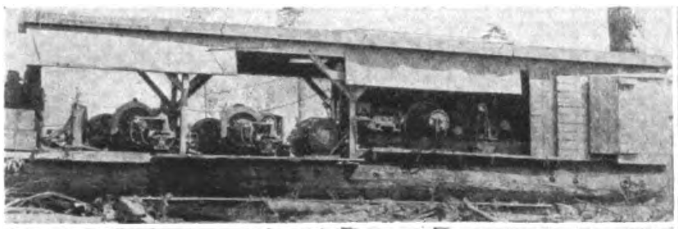
An example of electrified logging operations in California.

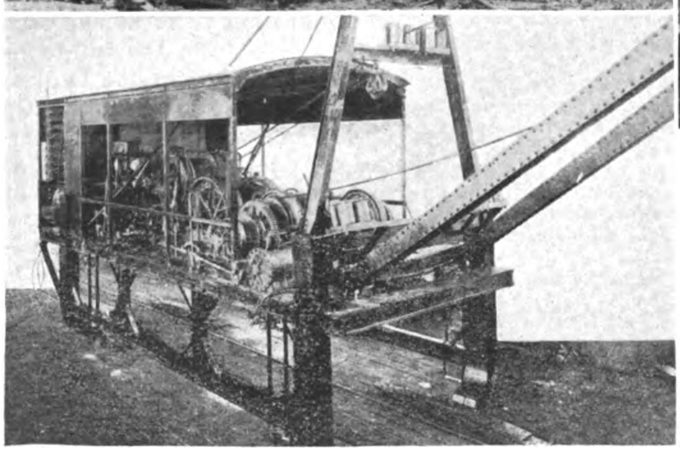
This shows the method of loading the logs on a flat car for shipment to the saw mill. Here the combined electric loader and duplex yarder is used in connection with a spar tree, to gather the logs from where they lie when cut to the central loading space. This enables the machine to cover a large area at a time. The loader then lifts the logs on a car. The current transformer is also on skids nearby, but is not shown in this illustration. These transformers must be of sufficient capacity to handle the high peaks without too much voltage drop, but the main transformer bank supplying power to an entire woods operation can be much less than the sum of the individual transformers' capacities owing to the high diversity factor.

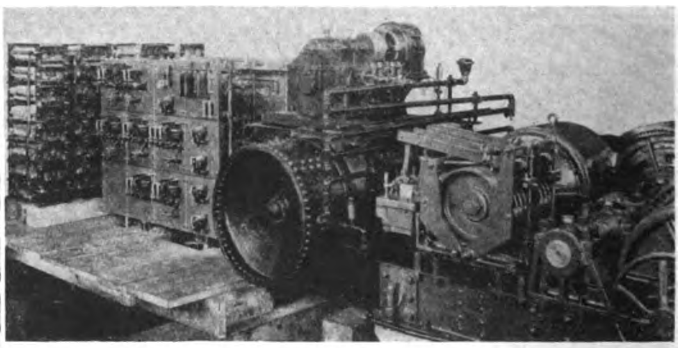
Two complete woods operations in California are now fully electrically equipped. The Hutchinson Lumber Company at Oroville, Calif., has eight yarders and eight loaders, and the Sugar Pine Lumber Company at Fresno, Calif., has eight yarders, six loaders and four boom skidders. Some of the accompanying photographs show the electrical equipment in use on logging operations of these two companies.

Power is transmitted to the woods at a line voltage of about 22,000 volts, where it is stepped down to 11,000 volts and distributed to the various transformers supplying power for the yarders and loaders. These transformer installations consist of three-phase, oil-insulated, self-cooled transformers, mounted on skids and located near the piece of equipment to be served. The transformers are rated at about 450 kva. and supply power to the equipment through flexible armored cable varying in length from 250 ft. to 500 ft., at a secondary voltage of 600 volts, three-phase, sixty cycles, alternating current.

The woods equipment frequently consists of a yarder to drag or carry the logs to a central point and a

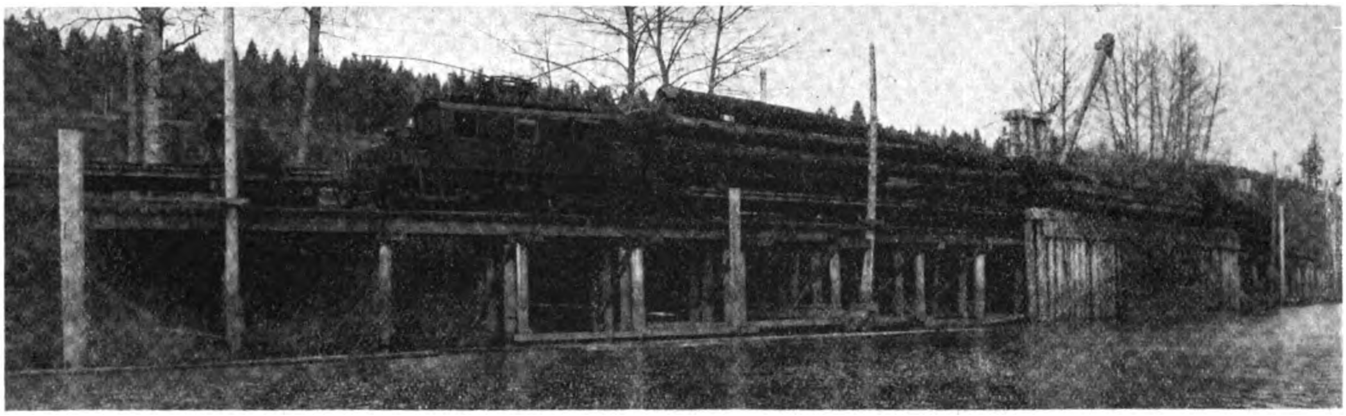






Three detailed views of electrified logging equipment.

The upper picture (left) shows a close-up view of a combined electric yarder and duplex loader similar to the one at the top of the page. This equipment is mounted on skids and is shown here loaded on a flat car ready to be moved. This outfit has 300-hp., 60-cycle, three-phase, 600-r.p.m., 550-volt motors on the loaders. The illustration above shows in more detail the control panels, starting and regulating resistors, air compressors, air tank, and solenoid brakes. The illustration at the left is of an electric boom skidder, one of the latest pieces of electrical equipment to be used in the lumber industry of the West. This machine is a combined yarder and loader and derives its name from the fact that it skids the logs in, instead of using a spar tree. This machine is large enough to straddle the railroad track and the empty flat cars to be loaded pass beneath it. When it is desired to move the equipment a flat car is run beneath it and the skidder jacked up on the car.



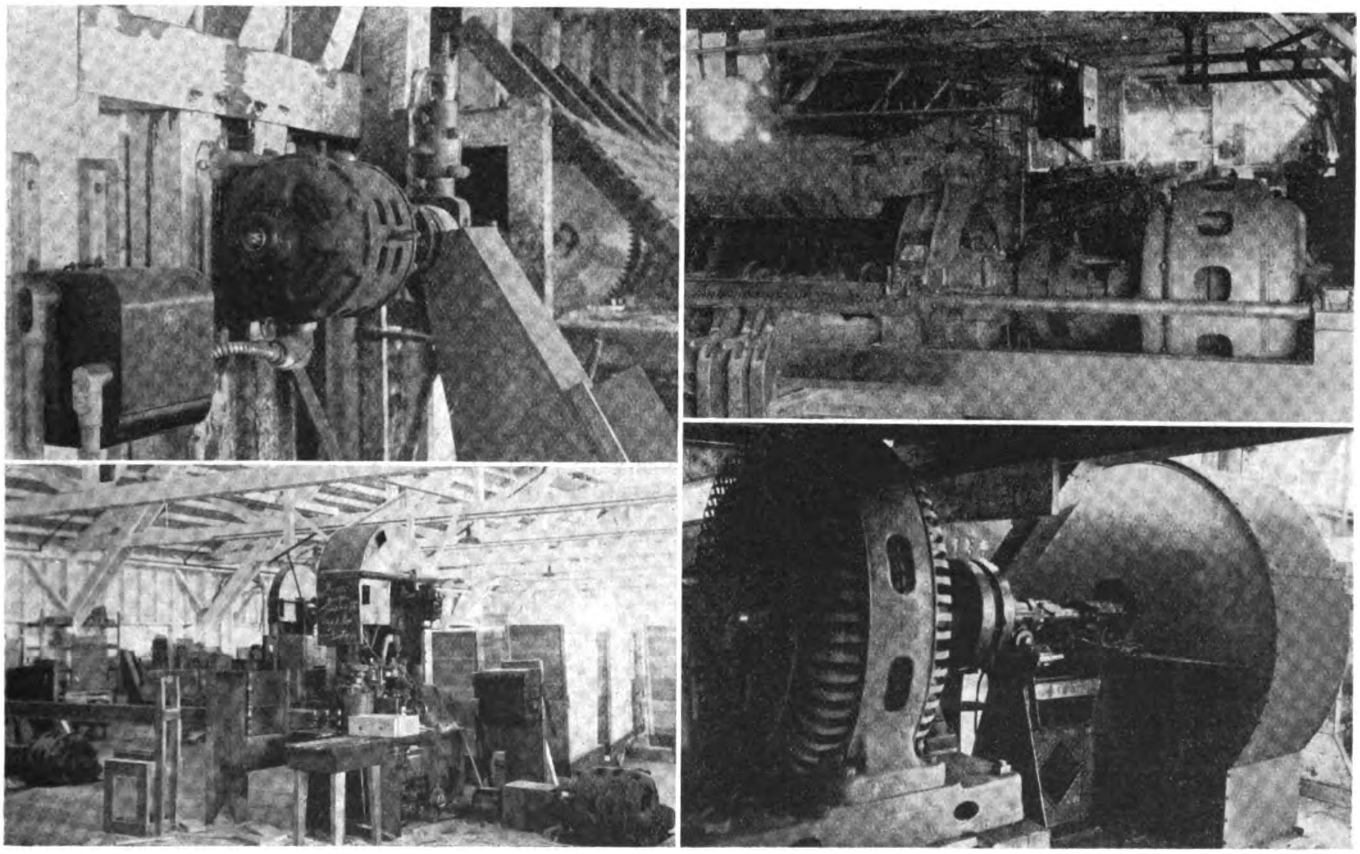
Here the fire hazard is further reduced by the use of electric locomotives in logging operations.

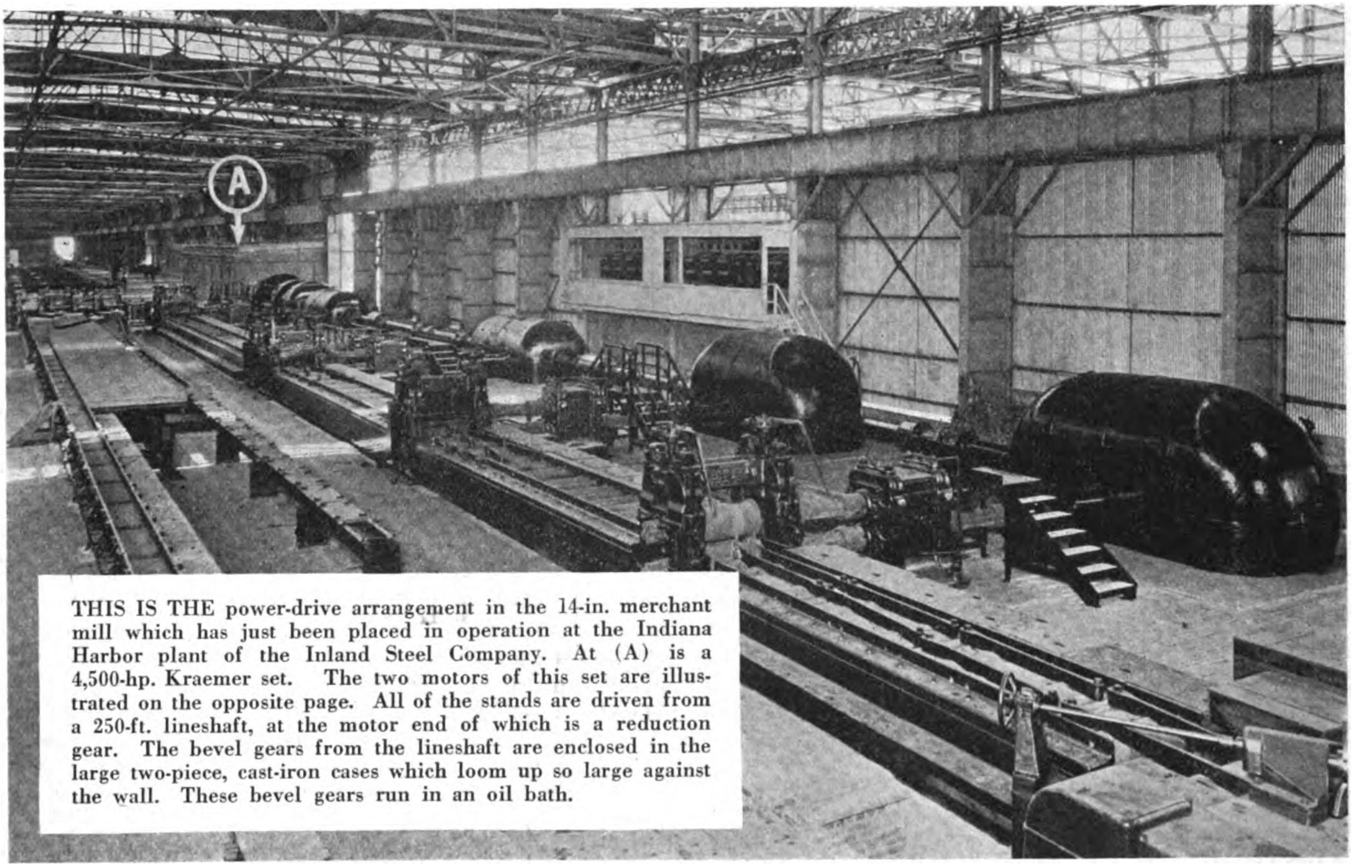
duplex loader to load the logs on the cars for shipment to the mills or to a waterway to float them down. Such a typical machine would probably have one 300-hp. motor on the yarder and a 75-hp. motor on each of the loader drums. All motors used on such equipment are variable-speed, slip-ring motors designed for maximum starting torque. Two principal speeds are used on the yarder which are obtained by means of gears, one giving a lineal speed on the main line of about 355 ft. per min. for starting the pull, and the other giving a speed of 770 ft. per min. for completing the haul of the log to the loading point. Extra-heavy type motors and control equipment have been developed especially for this service. The controls are of the contactor type operated by a master controller. The rigs are all equipped with air compressor and tank for operating gear shifts and drum frictions.

Four electrical installations in Pacific Coast saw mills.

In the upper illustration at the left a 25-hp. motor drives a slasher in a box mill. The 54-in. band resaw (lower left) is driven by a 50-hp., 575-r.p.m. motor. An edger (upper right) is driven by a 300-hp., 1,200-r.p.m. motor. Power factor correction is obtained by the 500-kva., 440-volt, 690-r.p.m. synchronous condenser (lower right) connected to a blower. This has 500-kva. condenser capacity and 150-hp. mechanical load capacity.

Most lumber companies purchase power from a power company when available, due to the poor load factor in woods operations. A typical installation consisting of eight machines would have a connected motor load of about 4,100 hp., with a peak of 3,500 kva., a 5-min. demand of 1,800 kva., and a monthly consumption of 145,000 kw.-hr., for a 10-hr. working *(Continued on page 458)*





THIS IS THE power-drive arrangement in the 14-in. merchant mill which has just been placed in operation at the Indiana Harbor plant of the Inland Steel Company. At (A) is a 4,500-hp. Kraemer set. The two motors of this set are illustrated on the opposite page. All of the stands are driven from a 250-ft. lineshaft, at the motor end of which is a reduction gear. The bevel gears from the lineshaft are enclosed in the large two-piece, cast-iron cases which loom up so large against the wall. These bevel gears run in an oil bath.

Some Trends and Recent Developments in

Problems of Steel Mill Operation

Involving the Use of Electrical and Mechanical Power-Drive Equipment, Together with Tendencies in Power Generation, Distribution and Application

By ARTHUR J. WHITCOMB*

Associate Editor, Industrial Engineer

ELECTRIFICATION has been the major trend for some time in steel mills. It was only a few years ago that electrical operation was unknown in the mills and now it is fast reaching the point where all power-driven apparatus, except possibly the blast-furnace blowers, is being electrified. The main drives of rolling mills are typical of progress in the electrification of steel mills. At the present time obsolete steam-engine drives are giving way in greater numbers to modern motor drives. This not only permits the replacement of engines whose economy varies with the physical condition of the engine but also eliminates individual boiler plants and long steam lines, thereby concentrating the generation of power in single and economical stations.

IN PREPARING this article, the writer visited nine large steel works noted for their modern equipment and progressive management. Not only operating men but also steel-mill consulting engineers were interviewed regarding new developments in steel-mill practice. This article represents what is being done in the industry and along what lines the men responsible for plant operations are thinking.

The Bethlehem Steel Company at its Lackawanna plant has installed a 7,000-hp., double-unit, reversing motor together with a flywheel motor-generator set which replaces a steam-engine drive on a 40-in. blooming mill. This equipment was placed in operation in May of this year. At this same plant there is being completed a 5,000-hp. installation of a reversing motor and flywheel motor-generator set which replaces the engine drive on a 48-in. universal plate mill. The Phoenix Iron Company has recently replaced engine drives on a

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24-in. structural mill and a 22-in. bar mill.

Another steel manufacturer has replaced the steam engine on the finishing stands of a rod mill. The roughing and intermediate stands of this mill are still engine driven and the speed of the engine varies considerably. Automatic control has been furnished to cause the speed of the 1,500-hp. motor to exactly follow that of the steam engine driving the first part of the mill.

The Carnegie Steel Company has recently contracted for two reversing motors complete with flywheel motor-generator sets which are to drive a 44-in. blooming mill and a 36-in. roughing mill located at its Homestead works. A motor drive for a 28-32-in. finishing mill has been contracted for. These three drives are part of an extensive building program planned for the replacement of old and obsolete equipment. These mills will take the place of three steam engine-driven structural mills, which will be dismantled.

In Great Britain, although electric drive of rolling mills is considerably on the increase, steam operation is by no means considered a back number. Over there, the erection of new mills and the modernizing of others has necessitated the construction of some very large steam engines for main roll drive.

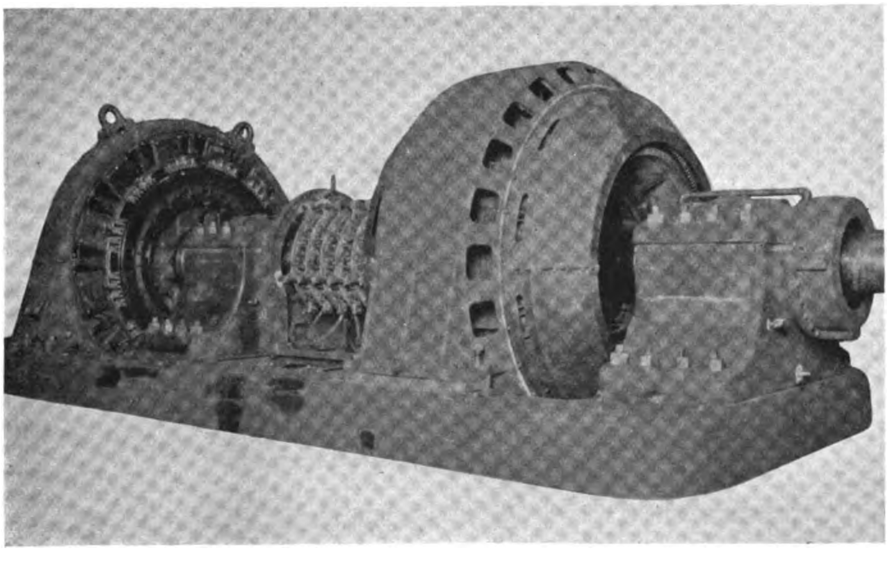
On the other hand, at the World Power Conference recently held at Wembly, England, a prominent German steel-mill engineer stated that the transmission of electrical energy over the distances encountered in steel plants does not entail more than ¼ to 1 per cent of the cost of high-tension, three-phase service and also that a motor running light does not take more than 3 per cent of its normal output. Tests made on a large steel works equipped with modern steam pipes have, he reports, shown that on a Sunday when all the engines were disconnected from the mills and run light, 60 per cent of the full-load steam requirements was used. The steam engines running light took 20 per cent and the remaining 40 per cent of the full-load steam requirements was lost in the steam pipes.

DURING the past twelve months the steel industry has passed through a period of very high production in which new record outputs were established, shortly followed by one of the most drastic slumps in its history, the worst of which now seems to have passed. Ordinarily such extremes are not conducive to marked or radical developments in the use of power-drive equipment. However, this period has been characterized by five outstanding tendencies and developments: namely, (1) Replacement of obsolete steam-engine drives with complete electrical operation. (2) Centralization of and use of larger units for power generation. (3) Installation of automatic substations. (4) The use of electric precipitation of dust in blast furnace gas. (5) Increased interest in the use of ball and roller bearings on mill-type and general-purpose motors. These developments together with other general trends in the industry are discussed in this article.

There is a marked trend towards the use of higher-speed induction motors geared to main-roll drives. This is due to the development of herringbone gears, which have reached a high degree of reliability and efficiency. One manufacturer of main-roll drives reports that 70 per cent of his equipment is for use on geared drives while another manufacturer states that 90 per cent of his new motors for main-roll drives are for geared service. It was only a few years ago that 25 cycles was popular in the steel mills because of the low speeds that could be obtained for use on direct connection of motor and rolls. This is quite the reverse from the present tendency to use higher-speed motors and has resulted in an increased use of 60-cycle power.

Among many other distinctive installations of electric rolling-mill equipment is the use of separate compound-wound, 240-volt motors on each of the four finishing stands which are arranged to form a continuous train in a 16-in. hot-strip mill. Two of the motors are rated at 1,500 hp. with 125 to 250 r.p.m. speed range, and the other two at 1,800 hp. with 165 to 350 r.p.m. speed range. These motors are said to be designed with such close inherent speed regulation that they operate throughout their range without any automatic, speed-regulating control. This drive is illustrated on page 411. It is believed to be the first installation of a drive for a continuous hot-strip mill train, which has been operated without special control for maintaining correct speed.

At the plant of the Inland Steel Company at Indiana Harbor, Ind., there has just been completed a 14-in. merchant or bar mill which is driven by what is said to be the largest Kraemer adjustable-speed set yet built. This set consists of a 4,500-hp., 500/300-r.p.m., 2,200-volt, 25-cycle induction motor, a 1,300-



This is said to be the largest, Kraemer, adjustable-speed set ever built in America.

This drive has just been placed in operation in the 14-in. merchant mill of the Inland Steel Company. The illustration shows the 4,500-hp., 2,200-volt induction motor and the 1,700-hp., 480-volt, direct-current motor which is directly coupled to it. The remainder of the set, a 1,350-hp. synchronous converter, is not shown. The equipment gives a speed range from 500 to 300 r.p.m. and drives the mill shown on the opposite page.

hp., 100-r.p.m., synchronous converter and a 1,700-hp., 500/300-r.p.m., direct-current motor. The induction motor and the d.c. motor are on the same shaft and are shown on page 409.

The Halcomb Steel Company, Syracuse, N. Y., is installing two polyphase, brush-shifting, alternating-current, adjustable-speed motors in its 9-in. and 14-in. merchant mills. One of these motors is illustrated on page 414. The manufacturer of this motor states that, without auxiliary apparatus, this motor gives adjustable speed that is practically independent of load. The motor has characteristics practically identical with the double-range Sherbius equipment and fills the need of an adjustable-speed a.c. drive where the power required is too small to make a Kraemer or Sherbius set feasible on account of the high initial cost of small installations.

Another interesting development has been made in the application of synchronous motors to main-roll drive. The manufacturers state that several successful installations were made during the past year.

Increased use of washed air for cooling main-drive motors is noted. Washing the cooling air not only supplies the motors with clean air, thus keeping them cleaner, but also by having the air intake outside of the motor room and having the motor room small, it keeps the motor-room atmosphere under pressure and thus keeps out some of the dirt that would otherwise drift in on the air currents from the mill.

Changes in Auxiliary-Drive Equipment

The mill-type, direct-current motor and the general-purpose, direct-current motor seem to be approaching the point where they are considered as standard. The only changes of note are in regard to the bearings, of which more will be said later in this article. With regard to alternating-current motors, particularly the squirrel-cage, general-purpose induction type, a number of improvements have been made. Several new motors have appeared on the market and older types of motors have been revamped to improve their characteristics. The points at which improvements have been made are in larger bearings and journals, better rotor construction, stronger feet on the stator, and improved insulation.

An enclosed type of collector has been developed for use on motor-driven gas compressors. The maker states that this has been accomplished by totally enclosing the rings in a sheet-steel drum through which air is forced by means of a separate, motor-driven blower.

There has also been developed the Fynn-Weichsel motor, which is said to combine the good characteristics of induction and synchronous motors with most of the undesirable ones eliminated. An interesting installation of these motors is being made in a drop-forging plant. The motor manufacturer reports that ten of the motors in that plant will be of squirrel-cage type while another ten of equal horsepower will be of the Fynn-Weichsel type. The latter will compensate for the low power factor of the squirrel-cage motors and the motor manufacturer states that this will give the entire installation unity power factor over practically the entire load range. Since this is the first installation of this type, the service results will be of much interest.

There is an increased tendency towards using the semi-enclosed type of motor instead of the open-type motor where adjustable-speed, direct-current motors are used on the mill floor. The use of gears and direct

Motor-Driven Main Drives Purchased During Past Year

Company	Mill	Drive	Motors No.	Motors Hp.	Volts	Cycles	R. P. M.
Atchison, Topeka & Sante Fe R. R. Co.	22-in. Bar		1	1500	2200	60	705
	12-in. Bar		1	400	2200	60	450
	9-in. Bar		1	400	2200	60	450
Bethlehem Steel Co.	48-in. Universal Plate	Direct	1	5000	700dc		0/120
	26-in. Rail	Gear	2	3000	6600		500
	Tin		3	1250	6600		250
			1	200	2200	25	363
Bryden Neverslip Co.			1	400	4000	60	440
			1	500	4000	60	440
			1	150	4000	60	353
Burlington Steel Co.	12-in. Merchant	Gear	1	1000	2200	25	750
Carnegie Steel Co.	44-in. Blooming	Direct	1	7000	700dc		0/120
	36-in. Rev. Roughing	Direct	1	5000	700dc		0/120
	28-32-in. Structural	Direct	1	6000	6600	25	98
			1	1000	6600	25	735
Crucible Steel Co.	16-in. Cogging	Gear	1	400	2200	60	705
	10-in. Finishing	Gear	1	700	2200	60	880/530
Gary Tube Co.	Piercing	Gear	1	2500	6600	25	347
	Seamless Tube	Gear	1	750	6600	25	295
Globe Steel Tube Co.	21-in. Roughing		1	800	2200	60	109
Jones & Laughlin Steel Corporation	14-in. Merchant		1	3000	600	dc	200/360
	14-in. Merchant		1	1700	600	dc	90/140
	14-in. Merchant		1	1700	600	dc	90/205
	14-in. Merchant		1	2100	600	dc	150/310
	14-in. Merchant		1	2100	600	dc	150/460
	14-in. Merchant		1	2000	600	dc	210/680
	14-in. Merchant		1	2000	600	dc	260/800
	14-in. Merchant		1	750	600	dc	360/860
Halcomb Steel Co.	12-in Roughing	Gear	1	350	2200	60	480
Kansas City Bolt & Nut Co.			1	750	2200	60	505
McConway Torley Co.	Tyre	Direct	1	500	220	dc	155/500
Pittsburgh Crucible Steel Co.	14-in. Finishing		2	750	250	dc	120/210
	18-in. Roughing		1	600	6600	25	368
J. A. Roebling Sons	Rod	Direct	1	1500	230	dc	475/510
Scullen Steel Co.			1	1500	2200	25	735
Sharon Steel Hoop Co.	Cold Roll	Direct	1	300	2200	60	352
Standard Seamless Tube Co.	Piercing		1	450	2200		720
	Tube		2	300	2200		400
Tennessee Coal, Iron & R. R. Co.	24-in. Structural		1	2000	6600	60	600
Timken Roller Bearing Co.	35-in. Blooming		1	1500	2200	60	355
Thomas Sheet Steel Co.			2	1200	2200	60	300
Universal Steel Co.	Roughing		1	500	2200	60	440
Westinghouse Electric & Mfg. Co.	18-in. Blading	Gear	1	350	230	dc	350
Wierton Steel Co.			1	1500	6600	60	257/508
			1	1500	6600	60	508
Youngstown Sheet & Tube Co.	Cold Roll	Gear	1	300	2200	60	440
	Cold Roll	Gear	1	300	2200	60	440
	COPPER, BRASS AND ZINC MILLS						
American Brass Co.	Rolling	Gear	1	400	2200	60	352
	Rolling	Gear	1	400	2200	60	440
	Rolling	Gear	1	400	2200	60	500
	Rolling	Gear	1	500	2200	60	595
	Rolling	Gear	1	800	2200	60	890
	Rolling	Gear	1	800	2200	60	890
American Metal Products Co.	Sheet	Gear	1	400	440	60	575
Baltimore Copper Smelting & Roll. Co.	Rolling	Rope	1	500	440	25	365
Hegler Zinc Co.	Roughing		1	250	440	60	585
	Finishing		2	245	230	dc	700/600
Illinois Zinc Co.	Sheet	Gear	1	450	230	dc	450
Rome Brass & Copper Co.			2	500	440	60	360
Scoville Mfg. Co.	Brass	Gear	1	750	4600	60	353
Standard Underground Cable Co.	Rod	Direct	1	800	440	60	353

For list of drives purchased prior to Aug. 1, 1923, see page 475 of the October, 1923, issue of INDUSTRIAL ENGINEER.

connection for auxiliary drives in steel mills seems to be supplanting chains or belts that have been used on a few of the auxiliary drives. This is probably due to the severity of shock encountered in the majority of steel-mill applications.

Trends in Use and Installation of Steel Mill Control

The method of regulating the acceleration of a motor controlled by an automatic controller has long been a subject for debate. At the present time the series relay is probably the most widely-used type in the steel mills. Relays utilizing the potential drop over the accelerating resistance are also in use. There seems, however, to be an increased use of the time-limit method of acceleration. Probably one of the main reasons for this is the desire for the simplest controller that can be obtained.

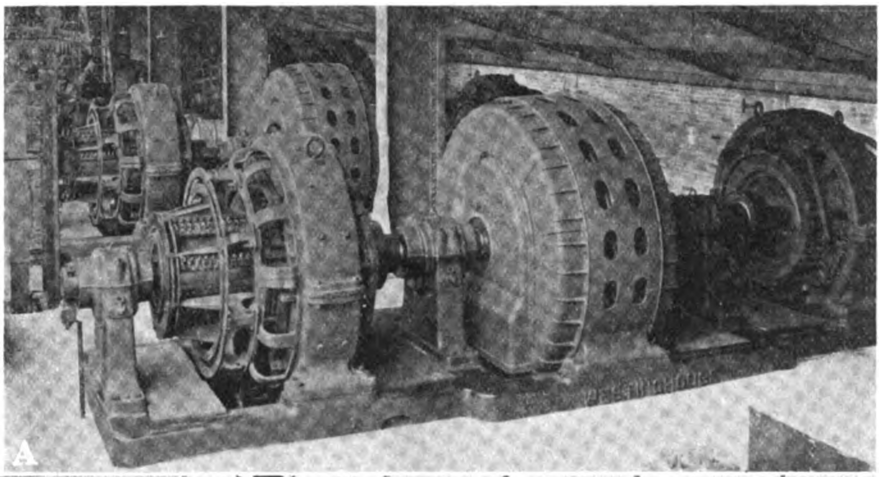
There is also a tendency towards a wider use of primary-resistance starters, for induction motors. One of the main arguments advanced in favor of the primary-resistance starter is its simplicity and the ease with which it may be repaired in case of trouble. This is something that appeals to the average operating man. One engineer whom the writer interviewed went so far as to say that in his belief the primary-resistance type of starter would be the eventual starter for this type of motor.

Standardization of resistors has been with us a long time and yet it does not seem to make as rapid headway as it should. At one plant recently visited the writer found possibly an extreme case of the cost of not standardizing resistors. In that plant after completing the installation of a new mill it was found necessary to buy $1,000 worth of resistors to provide adequate spare protection. The reason for this expenditure was because practically no two resistor frames in the installation were alike and interchangeable. This plant is now limiting control manufacturers to four sizes of resistor frames when buying new controllers. That is, in equipping a new mill with controllers, all of the control would be bought from one manufacturer and he would be limited to four sizes of resistor frames in designing the control. Some of the other plants visited were limiting manufacturers to five and six capacities of resistors. Still another plant buys its controllers without resistors and then purchases all of its resistors from one manufacturer, thus standardizing on one make of resistor and at the same time limiting the number of sizes. This latter plan has the disadvantage, however, that it is not so easy to hold the manufacturer accountable for the performance of his apparatus if he does not supply the controller complete with resistors.

One of the manufacturers has developed a railway resistor, which is interchangeable, both electrically and mechanically, with other resistors on the market. The unit consists of a sheet-steel, punched end frame with

Power-drive equipment of the four finishing stands of the 16-in. hot-strip mill of the West Leechburg Steel Company.

In illustration *A* is shown the two motor-generator sets which supply the power to four motors that individually drive the four finishing stands. Each set consists of a 2,200-volt synchronous motor which drives two 1,000-kw., 250-volt, direct-current generators that are designed for close voltage regulation. The two generators of each set are tied solidly in parallel and the two sets are operated in parallel. The single-pole, equalizer circuit breaker which makes the equalizing connection between the two sets may be seen in the foreground at the left. The four motors which these generators supply are shown in the background in the center of the illustration. In illustration *B* is shown one of the four motors. It is rated at 1,500 hp., 250 volts, 125 to 250 r.p.m. and is coupled directly to one of the four finishing stands. The remaining stands are each separately driven by similar motors, one rated at 1,500 hp. and the other two at 1,800 hp. Since the same strip of steel is in all four stands at once, each of the motors must run at a different speed, which must be maintained approximately constant irrespective of the fluctuations in the load, in order to avoid stretching or breaking the strip or excessively looping it. This condition is said to be obtained by the good inherent speed regulation of the motors themselves. In illustration *C* is shown the pulpit control desk from which the motor speeds are controlled.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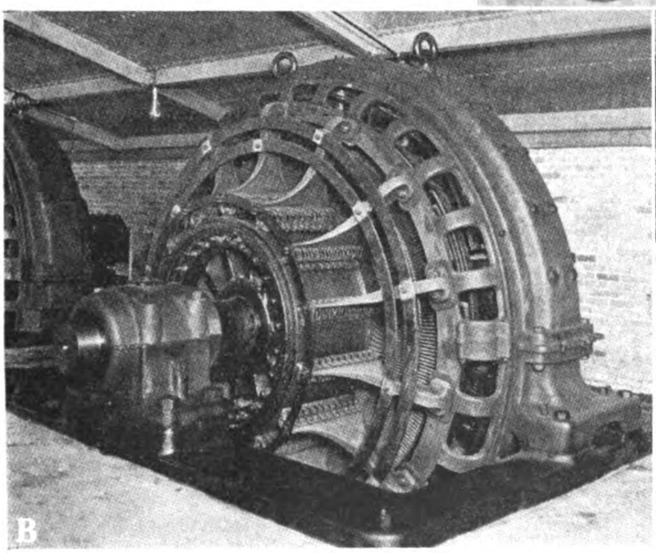
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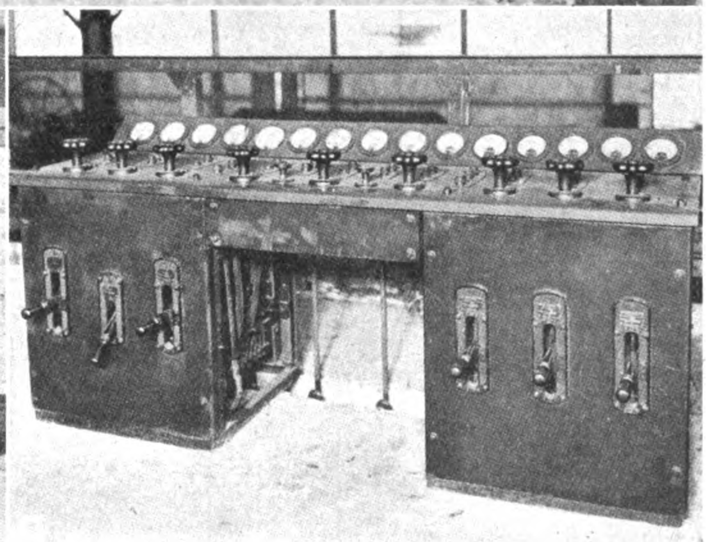
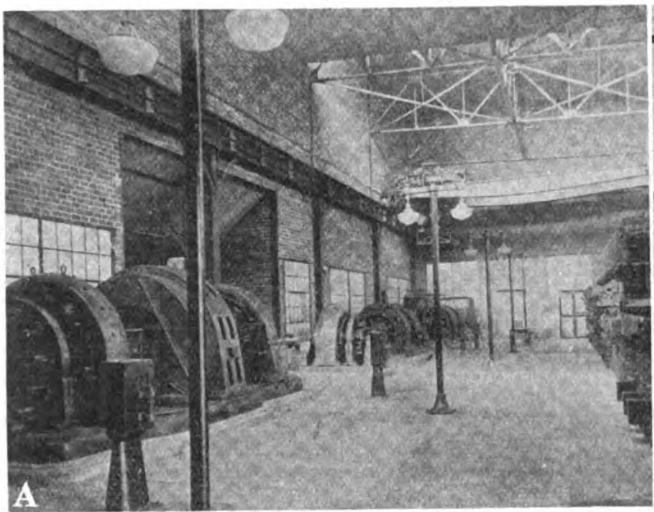


Eight Drives for Steel Mill Main Rolls

Showing Four Methods of Obtaining Adjustable Speed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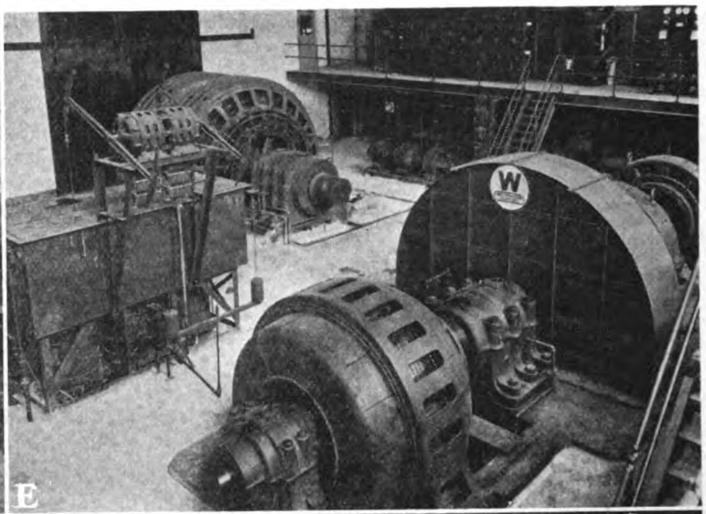
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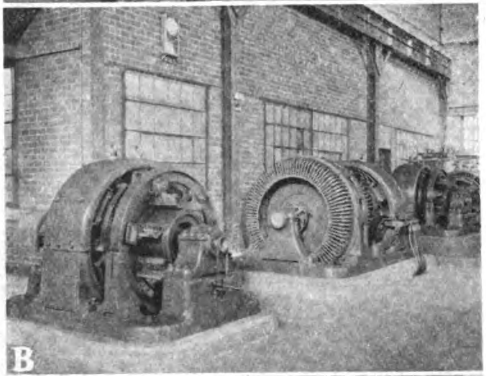

B

A—Rod-mill motor room in the Whitaker Glessner plant of the Wheeling Steel Corp. At the left is a 3,000-kw. motor-generator set. A closeup view of the other machines is shown in B.

B—At the left is an 800-hp., 706/320-r.p.m., 600-volt, d.c. motor driving the intermediate stand. The two 750-kw., 250-volt motor-generator sets supply the power for the auxiliary drives.

C—Frequency-converter, constant-horsepower, adjustable-speed set driving the 12-in. bar mill of the Scullen Steel Company, St. Louis, Mo.

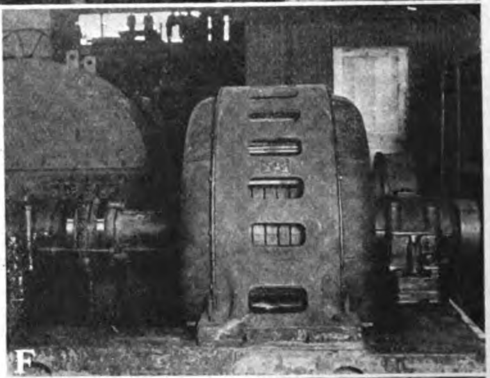
D—Two 2,000-hp., 83⅓-r.p.m., induction motors driving a plate mill of the Youngstown Sheet & Tube Co.

E—Motor room of the 44-in. blooming mill of the Bethlehem Steel Company at Steelton, Pa. A similar installation is just being completed at the Lackawanna plant.

F—A 1,500-hp., wound-rotor induction motor driving through a reduction gear the first group of roughing stands of the 16-in. hot-strip mill of the West Leechburg Steel Co.

G—The 1,000-hp., adjustable speed, Kraemer set driving the 12-in. merchant mill of the Central Steel Co.

H—Adjustable-speed, 2,000-hp., Kraemer set at the works of the Interstate Iron & Steel Co., Chicago, Ill.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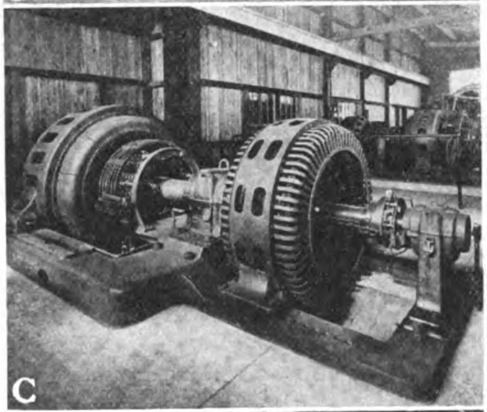
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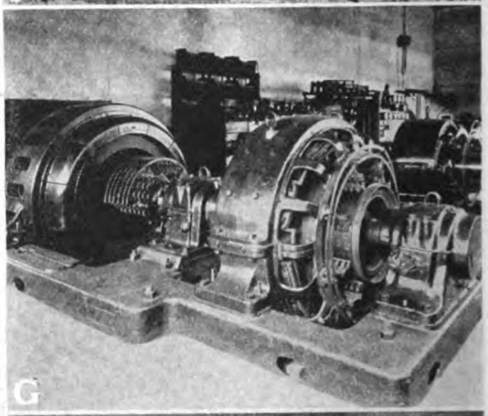
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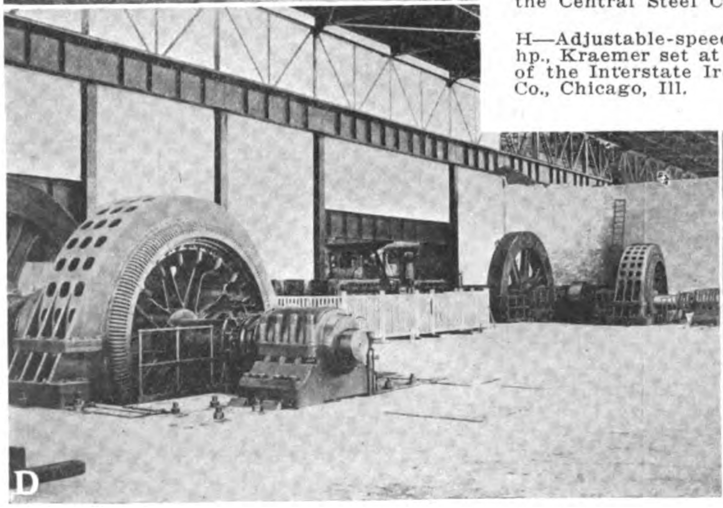
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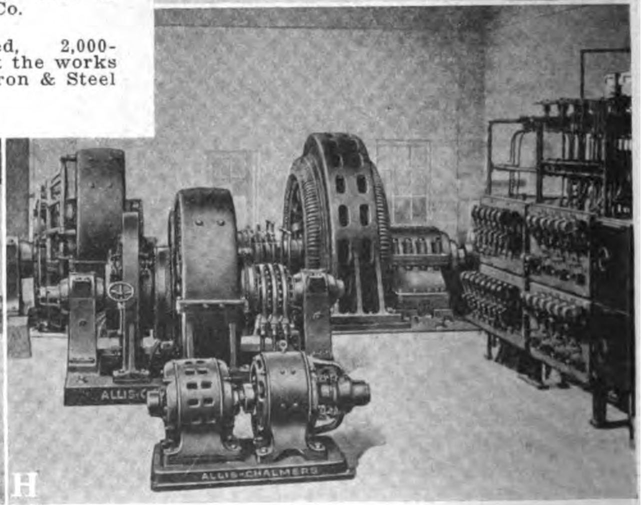


H

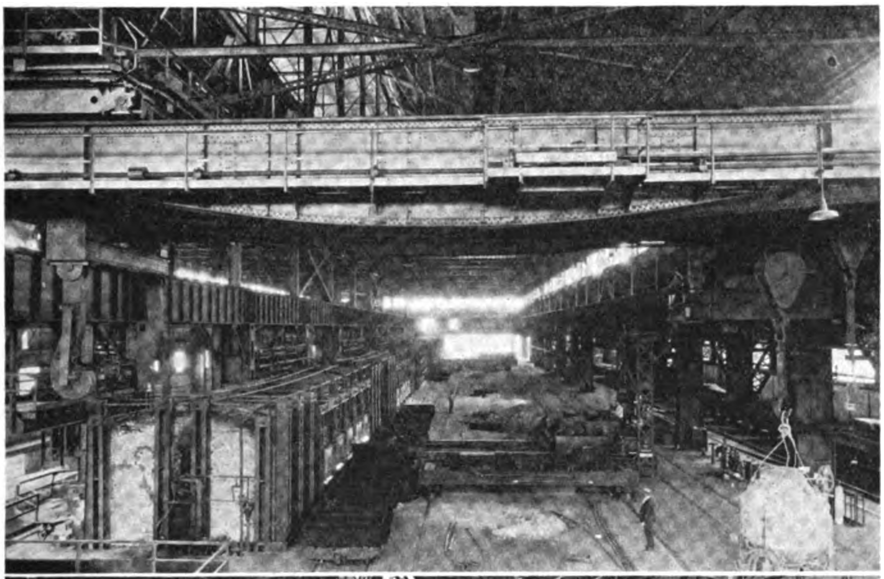
sufficient holes to make possible its support on the same bolt-hole centers as other generally used resistors. A new line of punched-steel resistors has been developed which the maker states are free from breakage and economical in space.

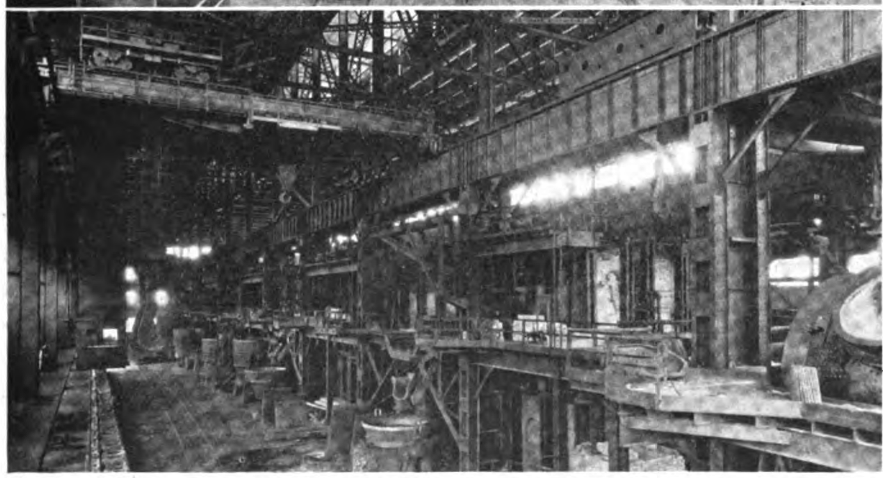
A manual controller for motor-operated skip hoists has been developed to compete with the steam-operated skip hoists used on small blast furnaces. An automatically-controlled, motor-operated skip hoist is rather expensive, except for the larger blast furnaces.

There is a decided trend towards much more substantial housing of the control apparatus. Not long ago it was common practice to put the control panels next to the walls of the mill floor without any protection except possibly a railing in front of the panel. The next step was to put the control panels on an open balcony. This was followed by the present practice of completely housing the control apparatus. At a mill which was recently completed the control is housed in a two-story brick structure, the lower floor of which holds the control panels, while the resistors were mounted on the upper floor. In another mill that has just gone into operation the control equipment is mounted on a balcony in the mill proper. This balcony is totally enclosed, has a good tight door and large windows so that one can see the motor controlled when standing in front of any panel. One of the objections advanced against a separate control house has been that it is impossible to see the action of the apparatus being controlled when standing near the control panel. The use of a long balcony with windows in the front does away with this objection. In places where the panels must be put in the mill proper, the tendency is to enclose the panel completely in a sheet-iron cabinet with doors on the front and rear, which are kept locked. Keys are given to authorized repairmen.

Special attention was paid to the safety provisions in this open hearth, which was completed this year at the South Chicago plant of the Wisconsin Steel Company.

Steel stairways are used throughout instead of ladders. A walkway is provided adjacent to each crane runway. All "live" electrical equipment is enclosed; in fact, the only exposed "hot" parts are the collector rails and these cannot be reached except from a ladder. The upper illustration shows the charging floor. One of the two 7½-ton floor charging cranes and the 100-ton hot-metal crane can be seen. The lower illustration shows the pouring side of the furnace. One of the two 175-ton pouring cranes may be seen.





In the same mill using the enclosed control balconies, a very flexible arrangement of conduit runs was noticed. The conduit running from the control balconies was grouped and carried along the side of the building as much as possible. At junction points wherever conduits ran to the individual motors a large junction box was installed and all conduits at that point were terminated in the box. This made several convenient points of access to each conduit running from the control balcony to each motor. This makes a system very much like an underground cable conduit system with manholes leading into the conduits at frequent intervals, with the exception, of course, that most of the conduit in the mill is on the walls of the building. The final stretch between the wall and motor is underground. This same mill used separate conduits for the shunt leads of compound-wound motors and also provided testing clips on each control panel so that a meter could be quickly inserted in the motor armature circuit without causing any interruption of the motor power supply.

Developments and Tendencies in Substations

One of the outstanding developments of the year has been the first installation in steel mills of fully-automatic control for motor-generator substations. The Edgar Thomson works of the Carnegie Steel Company at Pittsburgh has contracted for the necessary equipment to automatically control five motor-generator sets in three substations. The equipment is said to be full automatic and to provide for the automatic starting of machines by load demand and automatic stopping by the use of under-load relays. Pull-button switches are to be provided for starting and stopping the machines from the power house. Another equipment has been sold to the McKinney Steel Company and two more are to be installed at the Lackawanna plant of the Bethlehem Steel Company.

In talking with operating men the

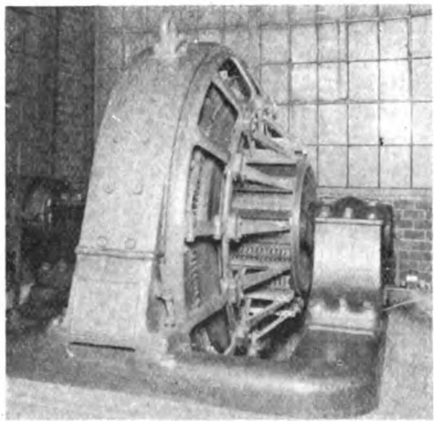
writer has found the consensus of opinion to be that automatic substations for steel-mill use are decidedly the coming thing. Some men stated that they could see application of automatic control only to isolated substations when there is no other equipment requiring an operator, such as an ore-dock, blast furnace, or open-hearth substation. Others, however, see a more universal application, believing that automatic control should be applied to the large mill motors, pumps, etc.

It has been felt by many engineers in the steel-mill industry that automatic-substation equipments would not necessarily be justified, due to the fact that the equipment is not spread over a large territory, but the importance of reducing labor costs seems to be overruling this opinion.

The automatic control at Edgar Thomson works is to be full automatic. Most operators approached on the subject seemed to have a preference for a control that would be handled by some central load dispatcher, as the power-house operator.

Some of the reasons advanced for the adoption of automatic substations are: (1) Eliminates operators; (2) makes no mistakes in switching; (3) does switching faster; (4) improves load factor, and (5) does things that an operator cannot do, such as discriminating between a gradually increasing overload and a suddenly applied overload.

With regard to the second reason mentioned above, R. F. Wensley has stated before the Association of Iron and Steel Electrical Engineers that on one large traction system, a careful analysis of maintenance costs actually showed that the cost per kilowatt of installed capacity for maintaining the automatic substations was less than that of the manual substations. Human failures causing expensive damage was the explanation. The automatic stations made no operating mistakes.



Roughing-stand motor in a rod and wire mill.

It is rated at 2,870/1,435 hp., 400/200 r.p.m., 600 volts direct current and is located at the Portsmouth works of the Wheeling Steel Corporation.

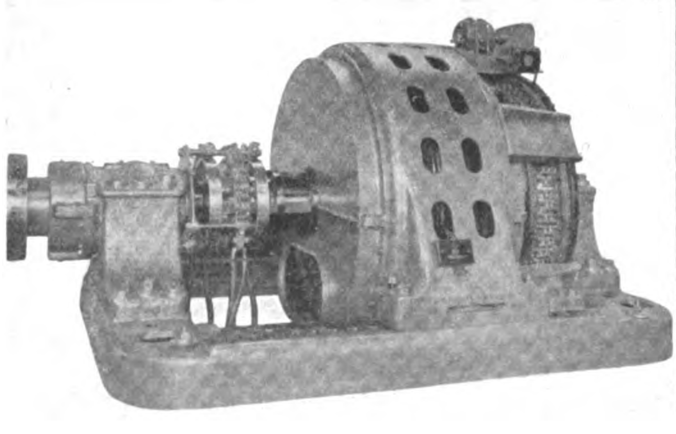
The left-hand illustration shows one of the two 600-hp., adjustable-speed, alternating-current motors now being installed at the Syracuse plant of the Halcomb Steel Co.

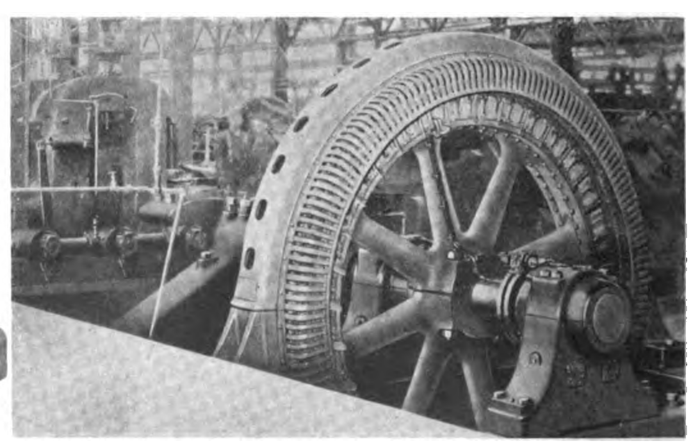
The motor has primary and secondary windings similar to a slip-ring induction motor except that the primary winding is placed on the rotor and the supply is connected to the slip rings. In the same slots as the primary winding is placed a regulating winding which is brought out to a commutator, shown at the right of the machine. The secondary or stator winding has each phase brought out separately, one end of the phase to one brush yoke and the other end to another brush yoke. The brush yokes are mounted one at each end of the commutator and are shifted by a mechanism constructed to move the brush yokes in opposite directions. The secondary winding is connected so that the circuit through each phase is completed by means of the commutator. When the brushes of both yokes are in line on the same commutator bar, the secondary phases are short circuited and the motor operates as an induction motor. Inasmuch as the regulating winding is placed in the same slots as the primary winding, an alternating voltage of constant flux is induced in the regulating winding by the primary flux. As the brushes are moved apart a section of the regulating winding is included in series with the secondary winding, thereby injecting into the secondary circuit a voltage which, by proper design, has the effect of changing the speed of the motor. This voltage may be made to assist or oppose the voltage of the secondary winding, thereby causing the motor to operate either above or below synchronous speed. The right-hand illustration shows an 800-hp., 2,200-volt, 60-cycle, 109-r.p.m., synchronous motor driving a tube mill of the Globe Steel Tube Company, Milwaukee, Wis.

Ever so often bobs up the old argument as to whether to use motor generators or rotary converters for converting alternating current to direct current in the steel mill. Motor generators have come to be regarded as almost the standard equipment for steel-mill use. Reasons for this, advanced by different operating men, are: (1) Simplicity; (2) reliability; (3) voltage control, and (4) power-factor correction, that may be obtained from the motor-generator set.

There is, however, an increasing tendency towards the use of rotary converters as is shown by several important installations that are being made. The main reason for this is that a gain in efficiency of approximately 4 per cent is obtained for the usual size of machine found in steel mills. This means a nice saving on all the direct-current power that is used. Other claims made in favor of the rotary converter as compared with the motor-generator set are: (1) The power-factor correction obtainable with the number of standard motor-generator sets in operation in a medium-size steel plant is not sufficient to be of much account. (2) It is cheaper to buy generator equipment to take care of the low power factor, since the short transmission distance leaves the transmission lines entirely out of the question.

In substation layouts the general tendency is to enclose all live parts possible and provide for greater safety. In a new substation being considered at one plant even the direct-current feeders will be controlled by remote-control, electrically-operated, carbon circuit breakers. The proposed installation will do away with the large knife





switches and will provide a more convenient arrangement of buses and outgoing feeders. The engineer in charge of the plant believes that the installation will be cheaper than an equipment of manually-operated circuit breakers with knife switches, etc., installed on the operating floor of the substation.

Trends and Tendencies in Power Generation

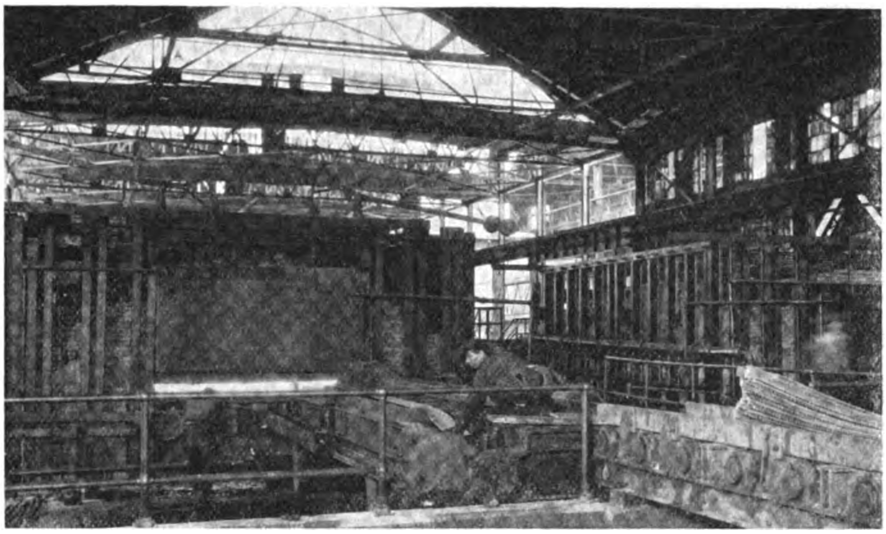
B. R. Shover, a steel-mill consulting engineer, at the recent World Power Conference at Wembly, England, pointed out the following as being the present and probably future tendencies of power generation in the iron and steel industry:

(1) Complete economical utilization of waste heat by converting it to steam to use in turbo-generators for electric power generation, except where this heat can be used to better advantage for a process in steel making or has a market value greater than its coal equivalent.

(2) Purchase of power requirements by plants which have no waste heat available.

(3) Interchange of electric power between plants generating power from waste heat and public service companies.

Centralization and the use of larger units are the predominating tendencies in power houses that are now being built in the steel mills. As would be expected, the steel mills are following the developments that have become established practice in the central-station field. Among the more important trends in the boiler house are the use of higher steam



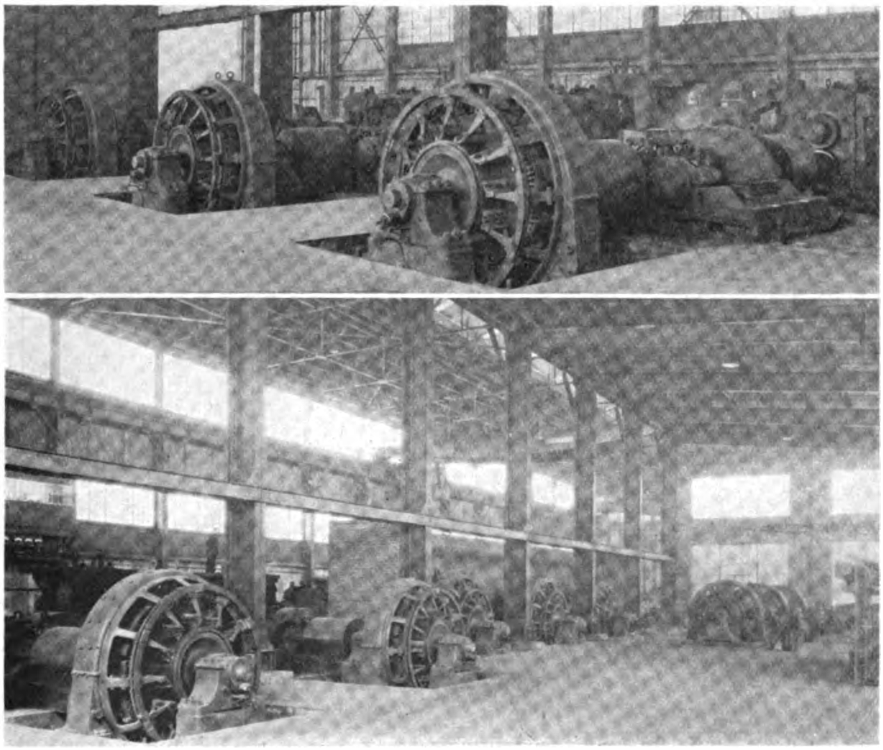
Magnetic charging machine which delivers the skelp into the furnace chamber.

The machine has two motor-driven, magnetic rollers upon which the skelp is laid. The magnetic attraction makes up for the lack of weight in the skelp and hence the tendency of the comparatively light skelp to slip off the rollers is overcome. This charging machine is in the butt-weld pipe mills at the Mark plant of the Youngstown Sheet & Tube Company.

pressure and larger boiler units. There was a time when 100-125 lb. was a very good steam pressure. Of more recent years 200 lb. has been more widely used. Several of the new steel-plant power houses will use 300 lb. steam pressure. This necessitates some radical changes in the boiler house, such as the use of welded pipe to take care of the higher pressures, the use of unusual expansion fittings and the like.

Many plants have several small boiler houses scattered around the plant and interconnected with pipe lines. In each of these boiler houses are several small units. The tendency is to consolidate the steam-generating equipment into one larger boiler house using large units. Some of the new boiler-house installations that are to be made in the steel mills will use 1,200-hp. boilers.

Blast-furnace gas is the main fuel used for power generation, in the steel mills. It may be converted into electrical power by means of gas-engine driven generators or by means of steam boilers and turbo-generators. Although the gas engine and alternator is undoubtedly the most economical combination for converting blast-furnace gas into electric power, the present tendency is to use boilers and turbo-generators. The reason for this trend is due to the fact that for an ordinary-size steel plant, the gas from at least three furnaces is required to furnish the power for the rolling mills. In case less than three furnaces are operating continuously, additional power must be obtained from steam standby service or from an outside source, because the gas engines cannot run from coal unless gas producers are maintained. Consequently the trend is towards the use of gas-fired boilers and turbo-generators. The boil-



Power drive of the 20-in. hot-strip mill of the Otis Steel Company, Cleveland, Ohio.

The upper illustration shows three 1,500-hp., 280/420-r.p.m., 600-volt, shunt-wound, direct-current motors driving the first three finishing stands. The lower illustration is a general view of the motor room. The two motors at the left are two of the three shown in the top illustration. In the center are three similar motors except that they are rated at 1,800 hp., 115/230 r.p.m. At the right are three 1,500-kw. synchronous converters.

ers can be arranged for the use of both coal and gas. Quite often the outside power is not to be obtained or if obtainable a high demand charge is required while the power is not being used.

More and more attention is being paid to the economies that can be effected in the day-to-day operation of the steel-plant power house. There is noticed a tendency to put more highly-trained men in charge of the power plant. To insure the attainment of the most efficient results, one steel plant has placed its power plant under the direct supervision of an engineer who is trained in central-station operation. The power plant is made into a department by itself with its head reporting directly to the chief engineer or general superintendent, as the case may be. The gas from the blast furnaces is metered before it reaches the boilers. The blast furnace is credited with the value of the gas furnished to the power house and the power house is charged for the gas. The power generated in the power house is metered on the high-tension feeders as it leaves the power house on its way to the various departments. Hence accurate costs of the operation of the power plant can be obtained, for it is possible to measure exactly all the raw materials and labor required for the production of power, and to measure accurately the output of the station.

Sixty Cycles and 2,300 Volts Becoming More Popular

The alternating-current voltages most popular for steel-mill use seem to be 2,300 volts for generation and distribution and 440 volts for the auxiliary, alternating-current motors. Since the distance from the power house in a medium-sized plant is seldom over a mile, the use of 2,300 volts usually gives the best all-around economy.

The trend is more and more towards the use of 60 cycles. The development of reliable and efficient gears has taken away the main advantage of 25 cycles (slow speed for direct drive) and 60-cycle energy, with the increased variety of speeds possible and the less expensive apparatus required, is growing rapidly in steel-mill usage.

In a recent extension to a 25-cycle power plant it was found cheaper to install a 60-cycle turbo-generator and a frequency converter to obtain the required 25-cycle power, than to install a 25-cycle turbo-generator. This places this plant in line to change to 60 cycles at some future date.

More attention is being paid to the ventilation of steel-plant power houses in order to eliminate as much of the dust as possible. At one plant visited by the writer an air washer in the basement drawing air from outdoors supplied washed air at different outlets on the turbine floor. This places the air in the room at a higher pressure than that outside the building; hence air will blow out of any window or other opening to the outside atmosphere and thus help to prevent dirt from entering the building. Arrangements have been made to heat the air in the winter time. A separate air washer is provided for the turbo-generator. It operates as a closed system; that is, the same air is continuously recirculated through the generator after being cooled by an air washer.

Marked Interest in Ball and Roller Bearings

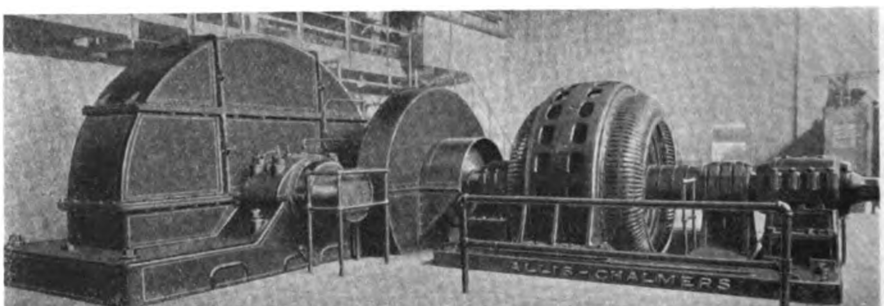
The subject of applying ball and roller bearings to electric motors has been before operating men of the iron and steel industry for several years. During the past year, however, a much greater interest has been shown. A number of steel-plant engineers have made applications of both ball and roller bearings and are very enthusiastic about the satisfactory results obtained. The writer has talked with a number of operating men who are either experimenting with ball and roller bearings or are about to do so. They feel that these bearings are the coming thing and are trying them out so as to have some service experience to guide them before making complete installations in their mills.

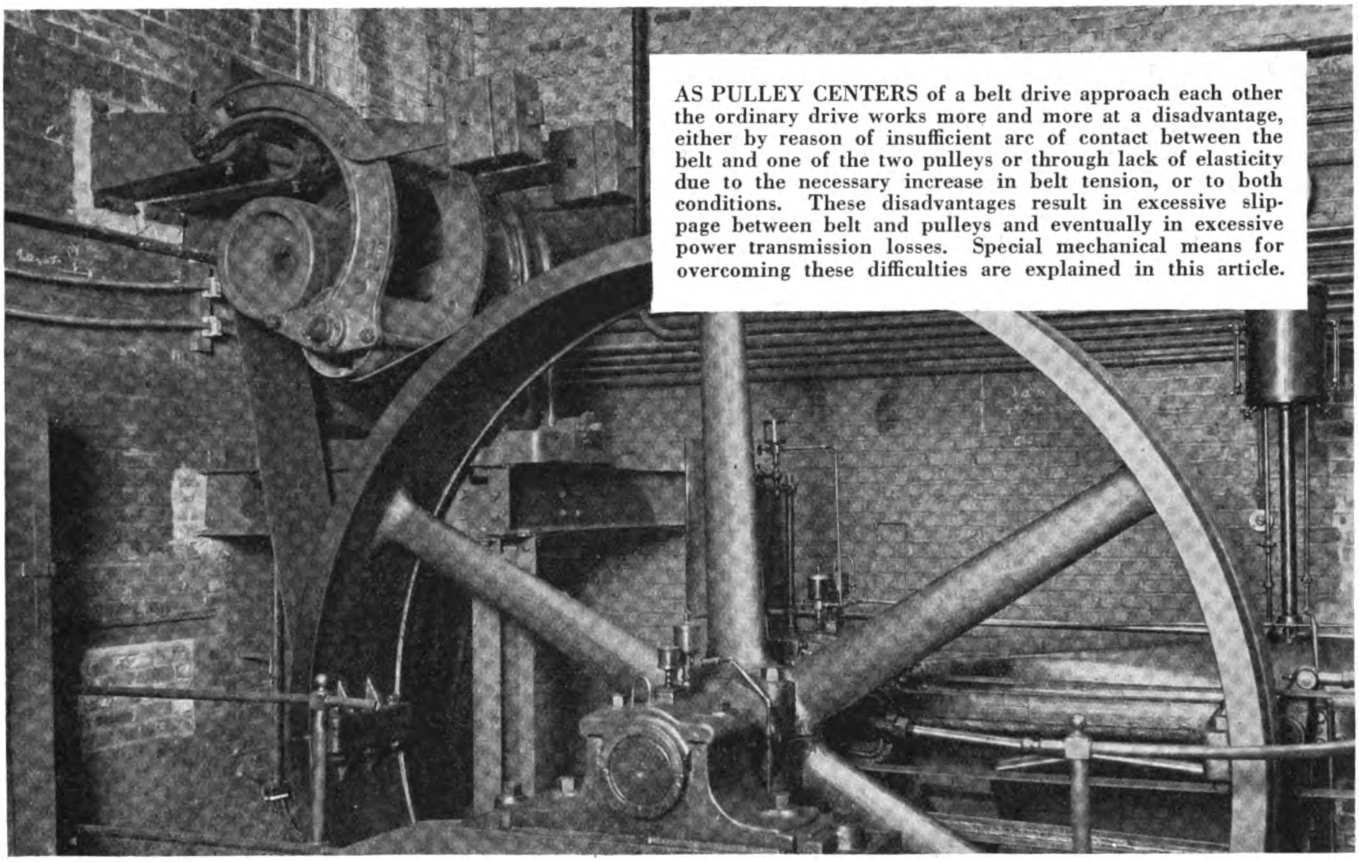
One large mill already has three-hundred sets in operation and another new mill is installing three-hundred sets of both ball and roller bearings with the idea of making a complete investigation of the subject.

Ball and roller bearings were first tried with the hope of getting away from oil troubles and of obtaining longer bearing life rather than in obtaining less friction loss. One large user claims that the following advantages have resulted in his use of these bearings: (1) Reduced electrical *(Continued on page 456)*

These two drives illustrate the tendency to use higher-speed motors driving through reduction gears.

The drive shown at the top is a 5,000-hp., 6,600-volt, 60-cycle, 595-r.p.m., slip-ring induction motor driving a rail mill of the Tennessee Coal, Iron & Railroad Company, Birmingham, Ala. In the lower illustration is shown the wound-rotor induction motor that drives the second group of roughing stands in the 16-in. hot strip mill of the West Leechburg Steel Company. It is rated at 1,500-hp., 2,200 volts, 60 cycles. On the pinion shaft of the reduction gear, which is coupled direct to the motor shaft, are two 31,500-lb., cast-steel flywheels, 74 in. in diameter. The secondary of the motor is provided with a slip regulator which automatically increases the resistance in the secondary of the motor and thus permits the flywheels to carry the peak of the load, thus lowering the demand on the power supply.





AS PULLEY CENTERS of a belt drive approach each other the ordinary drive works more and more at a disadvantage, either by reason of insufficient arc of contact between the belt and one of the two pulleys or through lack of elasticity due to the necessary increase in belt tension, or to both conditions. These disadvantages result in excessive slippage between belt and pulleys and eventually in excessive power transmission losses. Special mechanical means for overcoming these difficulties are explained in this article.

This shows how floor space may be conserved by compact drives. Originally this 90 kw. alternator was mounted on the floor alongside of the engine which drove a lineshaft on the other side of the brick wall. The patches show where the belt went through. Another belt came back from the lineshaft to the alternator. This drive which has belt centers of only 7 ft. 6 in. eliminated a lineshaft and another return belt.

Methods That May be Applied for

Increasing Arc of Contact With Low Belt Tension

In Belt Drive Installations Whereby the Distance Between Shafts May Be Shortened and the Pulley Ratios Increased over Ordinary Practice

By FRANK E. GOODING
Associate Editor, Industrial Engineer

BELT TENSION and arc of contact are two of the most important factors to be considered in a belt-drive installation. The arc of contact is determined by the ratio in sizes of the two pulleys and the distance between them, unless some mechanical means is used to increase this arc.

Ordinarily, belt tension is determined by the degree of tightness or looseness in the belt when it is put on. This is usually fixed by guess. However, a belt loosens as it wears in, and also the tension is affected somewhat by the atmospheric conditions. Each of these factors is of greater importance with large belts, as it is too expensive to allow an additional 25 or more per cent width to the belt and pulleys or an additional ply to take care of these fluctuations.

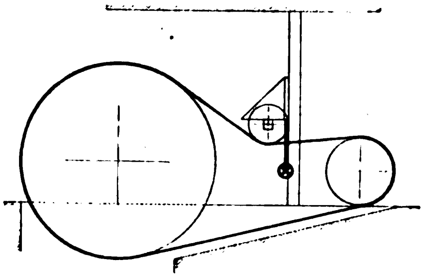
When belts were used on low-speed engines operating at 75 to 80 r.p.m. to drive lineshafts at 150 to 200 r.p.m., the distance between the shafts and the engine was usually great enough and large driven pulleys were used with a consequent low ratio in diameter between the driver and the driven, so that the arc of contact was sufficiently close to 180 deg., in most cases, to give a satisfactory drive. Also, as the distance between shafts was usually considerable, the weight of the belt caused enough dip in the slack side to increase the arc of contact on the small pulley. This also helped maintain a normal permanent tension on the pulley bearings, irrespective of the condition of the weather. In some cases belt dressings are used to permit a larger amount of slack in the belt and a consequent increase in the arc of contact. As a factory grows and the power to be transmitted by a main drive belt is increased above the original demand under which it was installed, slipping of the belt is a normal result. To prevent this, belts were often put on under such high tension as to cause bearing trouble, due to excessive pull.

More modern industrial practices have lead to the increased use of higher-speed motors of 600, 900 and 1,200 r.p.m., instead of engines, to drive machines and lineshafts. Although the speeds of lineshafts have

been increased to from 200 to 300 r.p.m., the ratio of the pulley diameter is greatly increased. This is because it is usually impractical to use an extra large diameter pulley on a machine or lineshaft; as a result it is necessary to use small pulleys on the driving motor. The expense of industrial space and the likelihood of extra long belts "flapping" have made it impractical to place the shafts much farther apart than was the previous practice. However, this increase in pulley ratios decreased the arc of contact on the smaller pulley.

The arc of contact on a belt drive installation may be determined by the special formula given by R. E. Moore, Chief Engineer of the Chas. A. Schieren Company, New York, N. Y., in his booklet entitled: "Practical Facts About Belting." The method of computation is reproduced in the box on this page. Also, this formula may be used as shown to determine the proper center distance necessary to obtain a satisfactory arc of contact. It is not recommended to use a drive with an arc less than 165 deg., and never less than 155 deg., on the small pulley without some means, such as an idler or other means of obtaining greater tension or arc on the pulley. Center distances, found satisfactory in practice as given by Mr. Moore, are 10 ft. to 12 ft., on small countershaft drives, using 2-in. to 6-in. belts; on medium countershaft drives, using 6-in. to 10-in. belts center distances of approximately 14 ft. to 18 ft. are used. On large countershaft drives with 10-in. belts and over, approximately 18 ft. to 25 ft. between shafts is satisfactory. On main drives with 12-in. belts and up, it is seldom practical to use a center distance over 35 ft., as it makes the belts too long and also adds to the cost. Where an excessively long center distance would be necessary to give the necessary arc of contact a shorter center with a flexible idler is often used.

Before discussing types of idlers, it may be well to say that in their use some practices detrimental to the belt are commonly observed. First, unless properly applied, they may exert too great tension. Second, the idlers are often too small in diameter for the thickness of the belts. Third, they cannot be used with any belt joint which does not give a smooth contact on both sides of the belt. The means of obtaining proper tension in the belt will be discussed later. A heavy belt cannot be bent around a pulley of small diameter without injury, even if the arc of contact of the idler pulley is small. The idler pulley should never be smaller in diameter than is recommended in the accompanying table, page 419, also given by R. E. Moore, for a minimum diameter of a driving or driven pulley. Also, it is seldom advisable, unless necessary, to use a three-ply belting because of the double flexure or reverse bending of the belt installation. A cemented endless belt joint will pass most readily through the reverse bend due to an idler and is recommended by belt manufacturers on all heavy driving installations. Wire or mechanical connections which bend on a hinge joint are next most satisfactory in operation if they offer a smooth surface in contact with the pulleys. Rawhide lacing gives an uneven surface on one side. Plates cannot be used as they would cause a jump or jerk of the belt on the bearings each time they passed under the idler pulley. If fabric belts are used they should be purchased endless for all

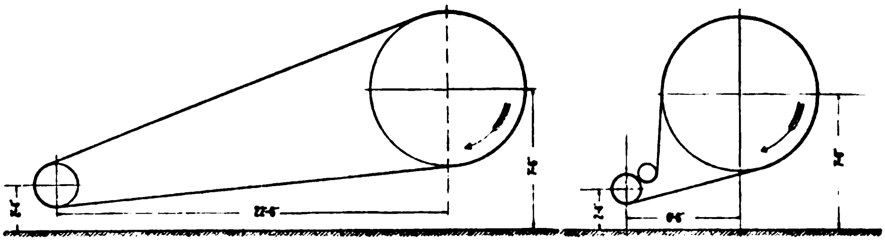


How the ordinary belt tightener idler is installed.

With tightening devices of this kind the additional driving power is obtained by increasing the tension of the belt. This increases the difficulty of lubrication. Also, it does not permit of any fluctuating tension in the belts, due to changes in atmospheric conditions except by the manual manipulation of the tightener. This type of tightener increases the arc of contact of the belt on the small pulley only a small amount.

This shows the saving of floor space possible through a short center drive.

In an ordinary belt drive pulley ratios of not over 1 to 5 are recommended and also sufficient center distances, as found by the formula in the box below, are necessary for satisfactory results. This shows how center distance may be decreased and the pulley ratios increased and still maintain the same circumferential belt contact on the small pulley by increasing the arc of contact.



Simple Method of Determining Arc of Contact and Center Distance of Open Drives

THE ARC of contact of a belt on the smaller pulley may be found by the use of the following empirical formula and reference to the table. Note that the diameter of the two pulleys is measured in *inches* and the center distance in *feet*. The formula is:

$$\frac{D - d \text{ (in } inches\text{)}}{\text{Center distance (in } feet\text{)}} = R$$

R is a ratio factor and by referring to the following table the corresponding arc of contact (without allowance for sag) may be determined.

Ratio R	Arc of Contact	Correction Factor
0	180 deg.	1.00
1	175 deg.	.97
2	170 deg.	.95
3	165 deg.	.92
4	160 deg.	.90
5	155 deg.	.87
6	150 deg.	.85
7	145 deg.	.82
8	140 deg.	.80

The correction factor is practically the efficiency of the belt due to the decreased arc of contact. Experience has shown that in laying out large compressor drives and drives with a large difference in diameter between the two pulleys the arc of contact on the smaller pulley should never be less than 155 deg. For good practice it has been found that an arc of contact of less than 165 deg. necessitates operating the belt under high tension.

Conversely, to determine the necessary center distance to be allowed in order to obtain a certain arc of contact on the smaller pulley: Divide the difference in diameter (in *inches*) of the two pulleys by the ratio factor R. (Refer to the table and choose value opposite the arc of contact desired.) This gives the center distance (in *feet*). Or, expressed as a formula:

$$\frac{D - d \text{ (in } inches\text{)}}{R} = \text{Center distance (in } feet\text{)}$$

NOTE: From "Practical Facts About Belting," Chas. A. Schieren Co., New York City.

cases where it is possible to install an endless belt.

There are in general two types of idlers used to tighten belts. One of these consists of a pulley which may be moved up or down, or horizontally, or on a slant by means of a screw or rack and pinion. Means are usually provided for locking the tightener in position so that it will maintain that tension and not slip back. This does not permit of reducing the high tension except by manual manipulation when the belt is idle, nor will it automatically compensate for atmospheric changes affecting the belts. Also, there is no means of judging the tension created except by guess with a resultant danger of too high pull on the bearings, which may cause bearing failure, and an excessive pull on the belt which may be great enough to exceed its elastic limit so that the belt will lose its power of returning to normal length and tension after it stops and may stretch excessively or finally pull apart. This type of tightener generally adds to the tension only as it is seldom placed near enough to the small pulley to add much to the arc of contact, as is shown in the sketch on page 418. This type of idlers is often used on conveyor belts and also operates satisfactorily on many slow-speed and some high-speed transmission installations.

Another common type of idler is one which applies an idler pulley on a swinging arm and maintains tension by means of counterweights or by springs, and may or may not have a means of varying the tension of the spring. There are many types of these and, of course, some are much better than others in that they are designed and attached more scientifically to the belt in relation to the load and service conditions. Many times these are homemade.

Five Advantages of the Belt Wrapping Drive

1—Increases the arc of contact between belt and pulley.
2—Maintains, constantly and accurately, the proper tension in the slack side of the belt.
3—Saves floor space, building space and belting because of freedom in pulley locations.
4—Saves in bearing friction, lubrication and renewal of bearings because of reduced bearing pressure.
5—Permits the use of less expensive, high speed and high efficiency motors or generators because of the higher pulley ratios.

Some of the causes of trouble from their operation results from their being weighted too heavily, causing excessive tension; pulley may be too small in diameter for the grade of belt; pulley may be too light or not applied with enough pressure and so bounce and cause fluctuating tension and a jerky drive. Many of these types do not have any means for easing up on this high tension when idle. Also in many cases they are not placed in the most advantageous location in relation to the pulleys. Perhaps the most common fault lies in that they are quite frequently designed primarily to increase the tension of the belt.

A well designed idler, such as the belt wrapping Lenix drive manufactured by F. L. Smidth & Company, 50 Church St., New York, N. Y., has the five points of advantage as given in the accompanying table. This device wraps the belt around the pulley and so increases the amount of belt surface in contact with the pulley, thus giving it increased pulling power without materially adding to the tension, except as increased tension is created by the greater amount of power transmitted.

An arc of contact, the first point, sufficient to transmit the load may be obtained naturally by the use of long pulley centers and slack belt. This, of course, involves a large amount of floor space. In some cases sufficient floor space is not available; in other cases it is not desirable or practicable to put the shafts far enough apart to give sufficient arc of contact to enable the belts to transmit the full amount of power. Also, if there is a large pulley ratio, it would not be practicable to put the belts far enough apart.

One artificial method of increasing this arc of contact between the pulley and the belt is by tension idlers, as explained, or by idlers of the flexible, resilient type which act as belt wrapping devices, as is shown in several of the accompanying illustrations. In illustration *A*, page 420, for example, a 1,400-hp. Corliss engine is driving a lineshaft pulley with a 50-in. three-ply belt. Before this drive was installed, the engine could not deliver more than 900 hp. to the lineshaft pulley, because through lack of sufficient arc of contact the belt would not hold on the pulley when the load was raised above 900 hp. The special drive attachment has wrapped itself around practically three-fourths of the circumference of the small pulley and enabled the belt to deliver the full 1,400 hp. to the lineshaft.

A good example of the method used to maintain the proper belt tension, the second point, is shown in the illustration *B*. Here two compressors each with two overhung flywheels and two three-ply belts are driven from a lineshaft. The shaft is in turn connected to a 200 hp. motor. For a year the plant endeavored to drive these compressors with open belts. However, as no two belts will stretch to the same degree it was impossible to keep both of them at the proper tension so that each would take an equal share of the load. With the special drive, as shown, applied in parallel to each belt the load is evenly divided between the two belts so that they automatically take care of periodically wide variations of the power demands of these double-belted compressors.

Saving floor space, the third point

Minimum Diameter of Pulleys Over Which Leather Belts May Be Successfully Operated

Width	Ply	Weight	Linear Velocity of Belt in Feet Per Minute		
			1,000	2,000	3,000 and up
Up to 8 in.	Single	Light Medium Heavy	2 in. 3 in. 4 in.	2½ in. 3½ in. 5 in.	3 in. 4 in. 6 in.
Up to 12 in.	Double	Light Medium Heavy	4 in. 8 in. 10 in.	5 in. 10 in. 13 in.	6 in. 12 in. 14 in.
Up to 24 in.	Triple	Heavy	24 in.	30 in.	36 in.

Five Examples of Lenix Drive Applications

Together with Some of the Power-Saving Features of Each

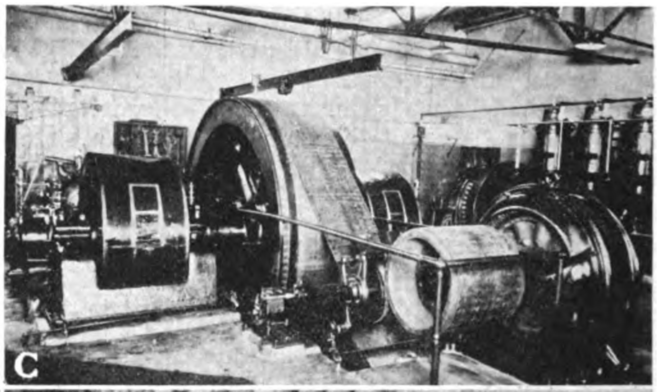
A—Practically three-fourths of the circumference of the lineshaft pulley is wrapped by the belt, which under ordinary conditions would hardly give an arc of contact much over 180 deg. Before this drive was installed the 50-in., three-ply belt drive would deliver little more than 900 hp. because there was not sufficient arc of contact on the lineshaft pulley. After the drive was installed, the full capacity of 1,400 hp. was obtained.

B—The proper belt tension is obtained by this special drive through the wrapping of the pulley and by the use of a counterweight. Each compressor has two belts driven from a lineshaft. This would not be possible without some device as this to maintain the proper tension in the belt, because ordinarily the two belts would not stretch or give equally and therefore one belt would be taking the load. The belt tension is maintained without a great increase in pressure on bearings.

C—The possibility of saving floor space by a closely-centered drive is shown here where the belt centers were shortened approximately 31 feet. As a result enough room was gained so that an additional unit could be installed. This 300-hp. gas-engine-driven, alternating-current generator is placed on pulley centers 10 ft. apart. The engine pulley is 114 in. in diameter and the generator pulley is 27 in. Another example of saving floor space is shown at the head of this article.

D—Reduced bearing pressure is obtained in this case by giving a much larger arc of contact to the small driving pulley and so placing more of the belt in contact with the pulley instead of pulling the belt so tight that it would not slip. If tension were obtained on this 200-hp. motor driving an ammonia compressor, by simply tightening the belt it would require a three-bearing motor instead of a two-bearing motor, at an additional original cost.

E—High pulley ratios are possible with a special drive of this type. With ordinary practice the natural arc of contact between two pulleys does not permit the use of pulleys of a ratio higher than 1 to 5, but the pulley ratio here is 1½ to 10.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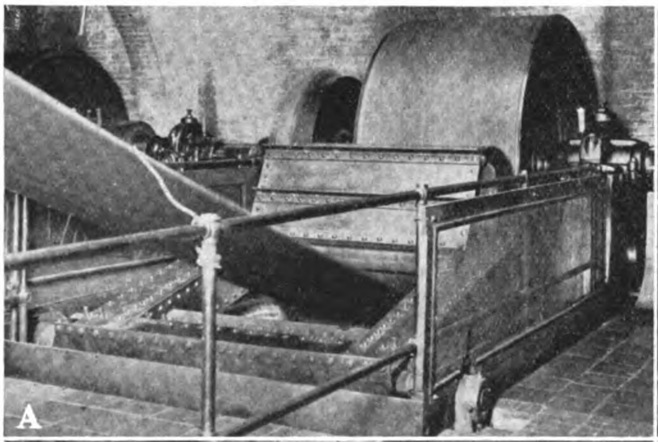
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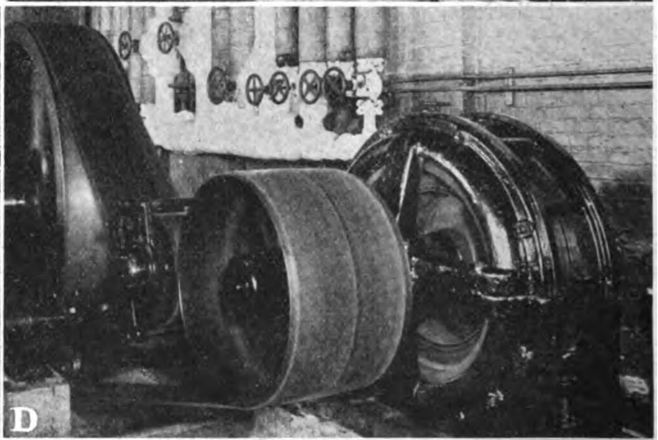
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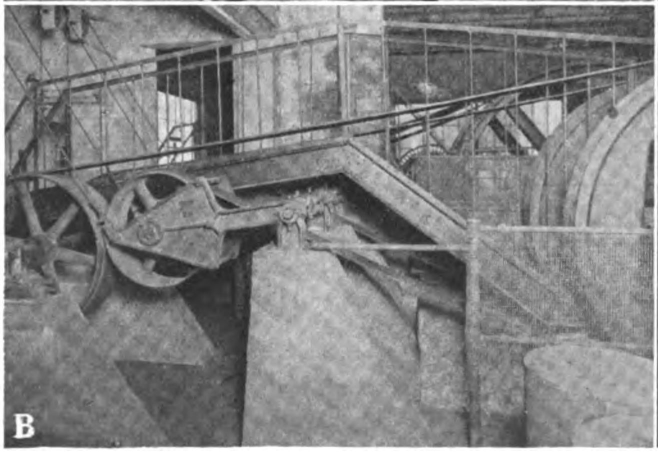
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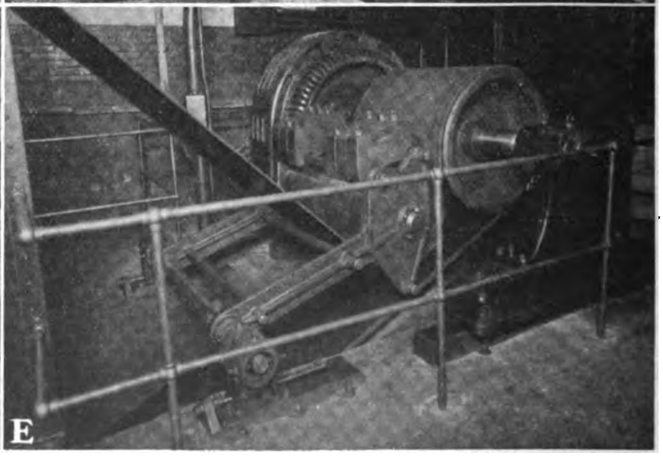
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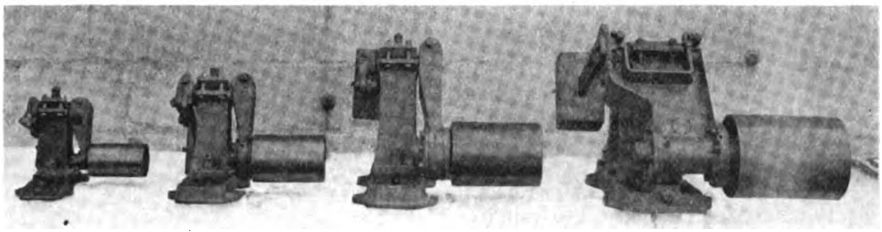


Four sizes of Lenix drives.
These drives, from left to right, are used on installations of from 2 to 15 hp., from 10 to 25 hp., from 20 to 50 hp., and from 40 to 100 hp. Drives larger than this are practically always made special as the conditions surrounding them are such that a standard design is not practicable.

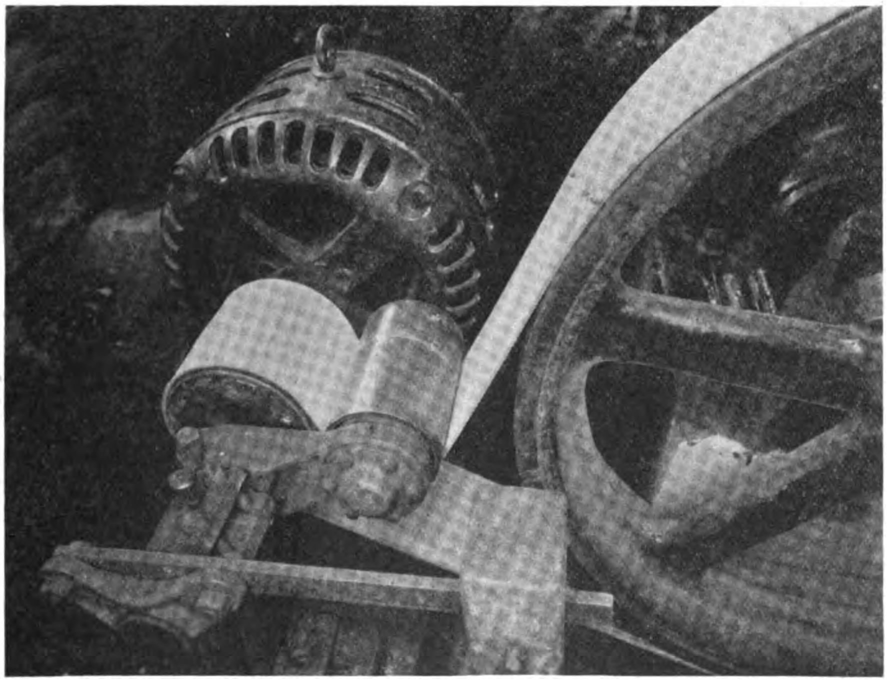
in this table, often becomes an important factor, especially when it is desired to add an additional unit. Enlarging the building is always expensive even if it is possible. However, due to the extra long belt centers which are often used in old installations, it is sometimes possible to put units closer together and so save enough floor space to install additional units. One example of this is shown in the illustration at *C*, page 420, where, when the two units were put close together with a special Lenix tightener, it was possible to shorten the belt center distance approximately 31 feet. This was a 300-hp. gas-engine-driven alternator with an engine pulley 114 in. in diameter and 31 in. face. The alternator pulley was 27 in. in diameter with 27 in. face. When the two were moved closer together the pulley centers were only 10 ft. apart. This not only gave room for an additional unit, but the drive also eliminated belt slipping and trouble generally and at the same time increased the capacity of the unit about 25 per cent by eliminating losses.

Another interesting example of saving space is shown in the illustration at the head of this article. Here a 90-kw. alternating-current generator is mounted on a platform back of the steam engine flywheel with an actual pulley center of only 7 ft. 6 in. The generator was originally mounted on the floor in what would be the foreground in the photograph. The patches in the brick wall show where the belt passed through the wall from the engine to a lineshaft in the next room. The belt passed back through the wall to the generator pulley. This installation not only eliminated one belt and a lineshaft but also freed the floor of the generator and the belt which formerly crossed it.

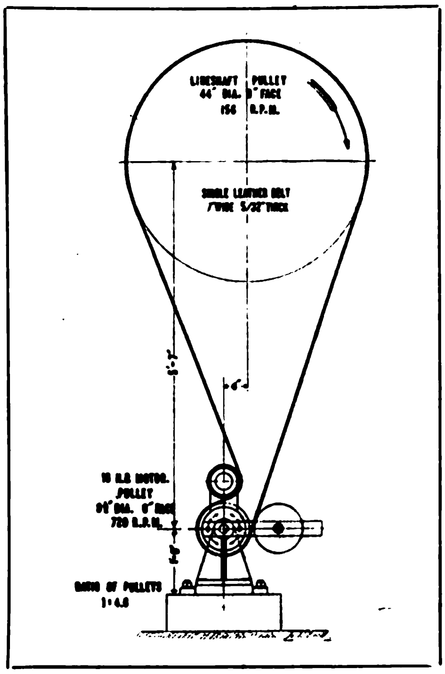
Reduced bearing pressure, the fourth point of advantage of drives of this type, offers a tangible saving to the users of belt drives by a decrease in friction loss and a saving in lubrication and power. Ordinarily in an open belt drive it is necessary to have an initial tension in the belt sufficient to transmit the power without slipping. This initial tension is often not so necessary in installations with belt width above normal rating for the load or with long pulley centers. A high initial tension causes an increased bearing pressure with continual unproductive operating friction losses which may result in a burned-out bearing. Wrapping the belt around the pulley gives more surface contact with the pulley and eliminates the need of this excessive tension. This is well illustrated in the 200-hp. two-bearing type motor driving the ammonia compressor shown in *D*, page 420. If it were necessary in this case to have a high initial tension in the belt it would require a three-bearing motor with an additional original cost.

High pulley ratios, the fifth point, are practically a necessity with the application of modern high-speed motors for the driving of industrial equipment or transmission lines. Ordinary belt practice limits the pulley ratio to about 1 to 5 on an open drive installation. The use of a high-speed motor requires a gear or worm speed reducer, a jackshaft reduction or a pulley diameter ratio much higher than the standard of 1 to 5. The illustration shown in *E* is of a 500 hp. motor driving an ammonia compressor with a pulley ratio of 1½ to 10. Installations have been made with a pulley ratio as high as 1 to 15. Such large ratios would be impossible if it were not for some such method as this of increasing the amount of belt in contact with the pulley. Without some such mechanical device as this the belt would touch only a small arc of the pulley and could not drive anywhere near its rated load.

If a low-speed motor had been supplied it would have added considerably to the installation cost. In addition low-speed motors operate at a slightly lower efficiency than do high-speed motors. While this difference is small it would amount to considerable over several years of operation on such a large installation as this one happens to be.

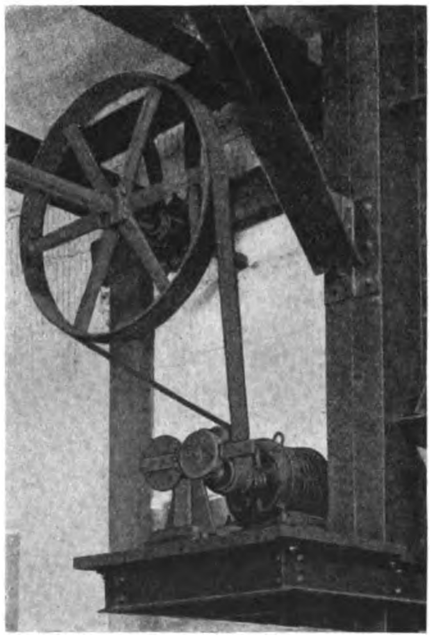


A ball-bearing idler drive is used between the motor and a compressor.
An 8-in. pulley is used on the 10-hp., 670 r.p.m. motor and is connected with a center distance of 2 ft. 11 in. to a 42-in. flywheel on the compressor by an 8-in. four-ply Goodyear light duck friction surface belt, made endless at the factory. It is always best to use endless belts on these drives because of the reverse bend when going over the idler. Practically all types of fasteners will cause the idler to jump somewhat as it goes under the idler.



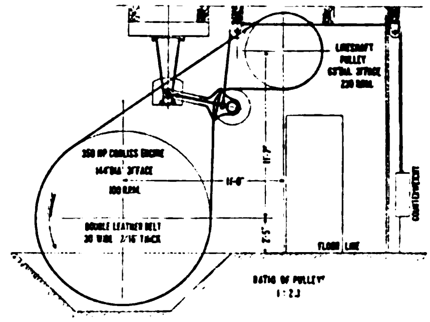
Ordinarily, it is not possible to install a driving motor directly under the lineshaft.

Ordinary practice requires that belts be installed at an angle of about 65 deg. as a maximum because otherwise too high tension would have to be maintained in the belt to prevent it from sagging from the lower pulley. Here the natural sag is taken advantage of to increase the arc of contact on the small driving pulley. This is a feature which has a wide application in lineshaft drives. The same plan can be used as advantageously if the small driving or driven pulley is placed overhead.



Another good example of the possibility of saving floor space.

Here is not only a short center drive but also a vertical drive where, under ordinary conditions, it would not be practical to use either. The starting equipment is mounted just below the motor platform.



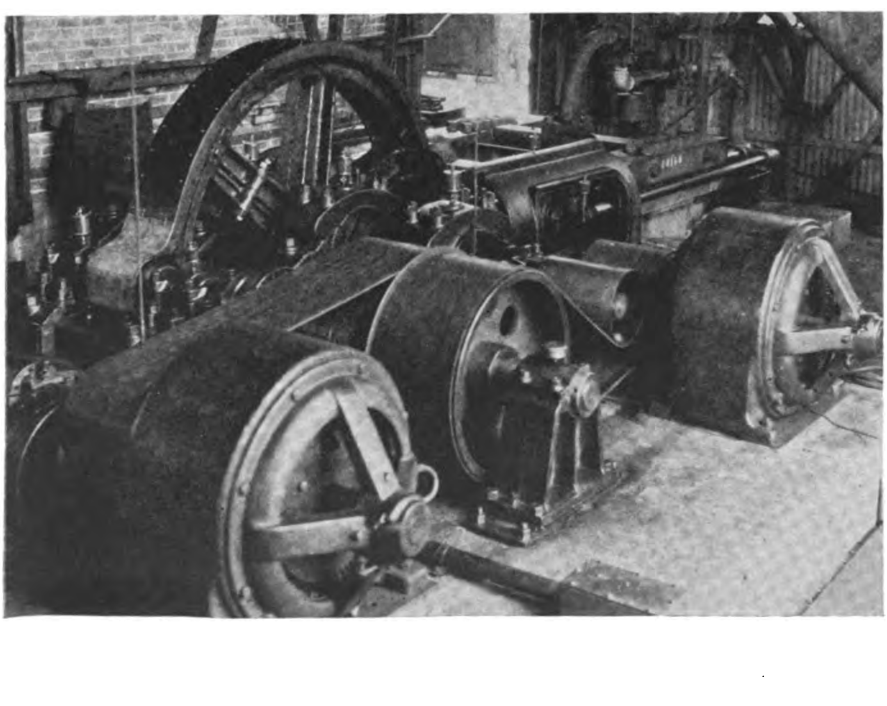
Before this drive was installed this belt gave considerable trouble.

Due to the fact that this drive had such short centers with the tight side at the top and the steep angle from the horizontal, it was necessary to shorten the 30-in. heavy double-belt frequently in order to maintain the heavy initial tension necessary to avoid slipping and burning. The newly tightened belt would transmit about 250 hp., but would have to be tightened again in about a month. With the increased arc of contact, due to the addition of the drive, the original belt now transmits regularly 300 hp. and is good for at least 350 hp. if necessary.

In the ordinary belting installation even with comparatively long centers it is not practical generally to use vertical drive; that is, to place the two shafts in a vertical line. Ordinary practice requires that the two shafts be at an angle not more than 65 deg. from the horizontal. As the angles of the two shafts approach the vertical there is a tendency for the belt to hang loose, due to its own weight, from the lower pulley. Two or three of the illustrations accompanying this article show how this belt wrapping drive may be applied to overcome this difficulty.

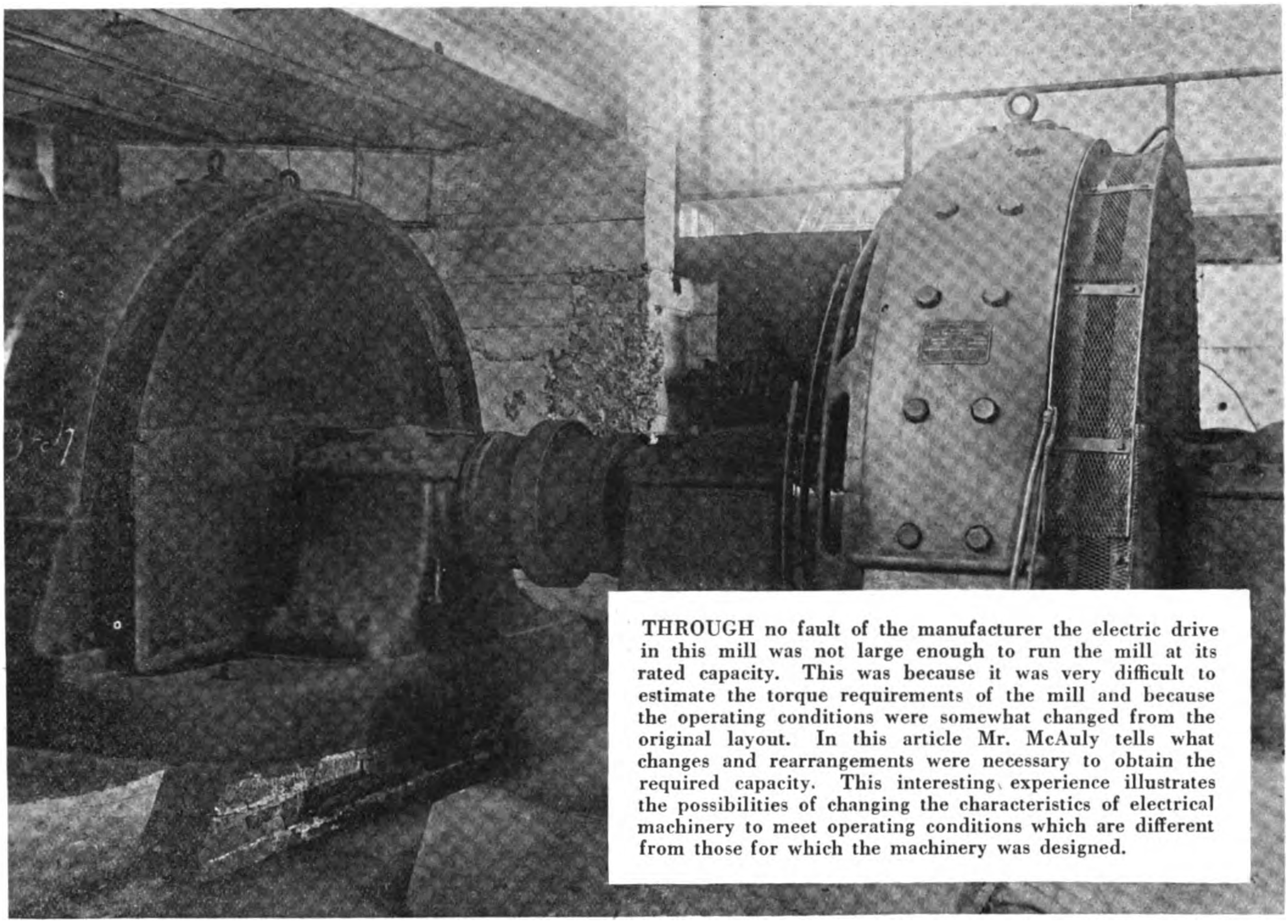
In one case, for example, this special overhead connection is used as the control for a paper beater. Here the two beater pulleys are on the floor above while the driving motor is connected through a shaft extension and flexible coupling directly to the 150-hp. motor. By means of an extension wheel on the floor above, the operator of the paper beater may disconnect either of the beaters from the motor, as shown on page 455.

In addition to the points which have already been covered, this type of drive has other special applications of interest. For example, in one case the starting duty of a motor on a tube mill in a cement works requires double the full-load torque. In addition the belt was subjected to sudden reversals of strain or tension from the tight side to the loose side of the belt. This presented an operating condition which would be very difficult to handle with open belt. However, the addition of an oil dash-pot to steady the drive when starting avoided all belt slipping and flapping during the starting period. After the drive is operating the drive returns to normal position and re-establishes the regular minimum amount of tension incidental to ordinary driving. Another interesting installation is in connection with a number of *(Continued on page 455)*



Driving this large hydraulic pump with two 140-hp. motors presented some out-of-the-ordinary problems.

When two motors are used to drive one machine, the most important problem is the accurate adjustment of the driving device so that each motor carries only its full share of the load. This makes it necessary to use some means whereby the tension is maintained equally on each belt irrespective of the fact that neither will stretch equally. Therefore, it was not possible to maintain tension by moving the motors on the slide rails, or to use fixed tension devices. However, belt drive is preferred here because of the amount of flexibility permitted between the motor and the pump. How these drivers and motors were installed may be seen from the illustration.



THROUGH no fault of the manufacturer the electric drive in this mill was not large enough to run the mill at its rated capacity. This was because it was very difficult to estimate the torque requirements of the mill and because the operating conditions were somewhat changed from the original layout. In this article Mr. McAuly tells what changes and rearrangements were necessary to obtain the required capacity. This interesting experience illustrates the possibilities of changing the characteristics of electrical machinery to meet operating conditions which are different from those for which the machinery was designed.

Fig. 1—Motors in tandem driving the roughing stands of a tire mill. In the original installation the left-hand motor was located on the foundation where the right-hand motor is now placed. As the one motor did not have power enough to drive the roughing mill, a duplicate motor, except that it had a larger shaft, was obtained and installed as shown.

Experiences When

Changing a Steel Mill Main Roll Motor Drive

To Give Increased Capacity Together with Details of the Installation and Rearrangement of the Equipment

By A. W. McAULY
Chief Electrician, Edgewater Steel Co., Pittsburgh, Pa.

AMONG many other installation jobs in an old steel plant that was undergoing an almost complete rebuilding, was the installation of a complete electric drive for a rolling mill. This mill was a tire mill and consisted of two main drives: a roughing mill and a finishing mill. Due to the special character of the work to be done by the mill, the torque requirements could not be accurately determined in advance so what was supposed to be due allowance as a safety factor was made and the electric equipment ordered. Since variable speed was required, it was decided to use an Ilgner system or Ward-Leonard system with the addition of a fly-wheel for the motor control.

Two sets of equal size were ordered, one for the roughing-mill drive and the other for the finishing-mill drive. Each set consisted of a 750-hp., 600-volt, direct-current, 160-r.p.m., shunt-wound, 1100-amp. motor supplied with variable-voltage, direct-current power from a fly-wheel, motor-generator set, consisting of an 850-hp., 2200-volt, 3-phase, 60-cycle, wound-rotor, induction motor, a 12½-ton flywheel and a 750-kw., 600-volt, compound-wound, direct-current generator. In addition to this, there was a slip regulator to control the power input to the motor of the flywheel motor-generator set and a 10-kw., 125-volt, direct-current, compound-wound, exciter for furnishing the field excitation of the mill motor and the generator supplying it. The exciter was driven by a small induction motor. There were also switchboard control panels, master controllers and other miscellaneous apparatus.

As the buildings which were to house the mill equipment formed a part of the old plant, it was necessary to install the motors in a pit in one of the mill buildings. Consequently, no motor house could be planned. The motor-generator set with switchboards and control equipment was to be installed in a substation 100 ft. or so from the building housing the mill. Foundations

for the mill motors were laid, cable trenches were dug, and fibre conduit laid in cement to take the lead-covered cable between the substation and the mill. Traveling cranes were available in the mill building for the erection of the mill motors but there was no crane in the substation. The heaviest parts to be handled in this building were the 12½-ton flywheels, so the erecting equipment was planned accordingly.

The floor of this building is of reinforced concrete, 9 in. thick, supported from 24-in. I-beams spaced 4½ ft. apart, with a basement underneath. The available space was roughly 30 ft. by 60 ft. In this space were to be installed two flywheel motor-generator sets, two slip regulators, two exciter sets and the switchboard and auxiliary control apparatus. One bad feature was the necessity of cutting a slot in the concrete floor, 12 in. wide and 8 ft. long, for the lower part of each flywheel. Each set was located so that the slot would have a minimum weakening effect upon the floor. The weight of the parts to be handled and the strength of the handling equipment was very carefully considered. Two timbers about 14 in. square were set on end with a beam across the top and secured with angle iron and bolts. Heavy steel blocks were hung to this beam and were reeved with steel hoisting cable ¾ in. in diameter. A husky hand winch was secured to one side of the building, and this outfit together with jacks, bars, rollers and plenty of man power soon had the larger parts in place.

The bed plates were leveled, the machined surfaces and the pedestals carefully cleaned and the shims placed according to the numbering by the manufacturer. Special care was taken to protect the insulation from the slings used in handling the large pieces by the use of heavy hardwood planking to space the cables. Burlap was used on the cables where they looped around shafting. We tried to prevent the smallest amount of dirt from getting into the bearings during erection and apparently succeeded for no bearing trouble of any kind developed.

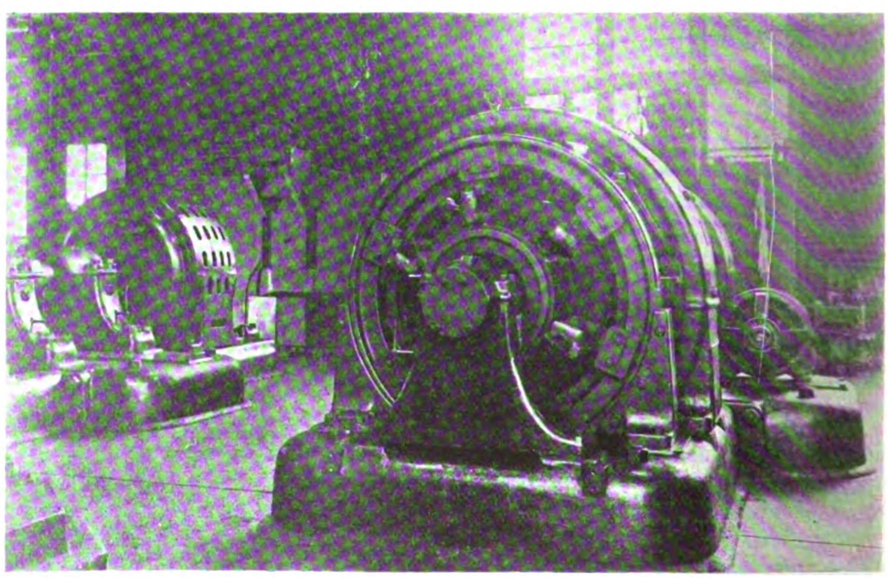
It may not be out of order to insert a word of caution here, for the benefit of those who have had no experience with heavy electrical machinery. The eye bolts should only be used to lift the top half of the frame and not the whole machine. The manufacturer should be asked for information bulletins regarding the installation well in advance of the arrival of the machinery. This provides an opportunity to procure any special tools or other apparatus needed for erection. The bed plates in many cases are liable to bend and crack, unless the weight is well distributed over the entire base, hence, when moving bed plates with machines assembled on them, end rollers should be used under the skids upon which the machine is shipped and not directly under the iron bed plates.

After the heavier parts of the installation in the substation were in place, the motors driving the main rolls were erected. Since there were cranes in the mill building, this was very easy after the hand methods necessary with the motor-generator sets and the work progressed rapidly.

The switchboard and control equipment now began to arrive. Boxes of all sizes by the dozen were unloaded from cars and trucks until it seemed as though we would be snowed under. However, by checking the crate numbers against the shipping lists, it was possible to determine the contents of most of the boxes without opening them. They were then tagged so that anyone could easily identify the needed box and piled in such a manner that the tags could be read without moving the boxes. Practically no trouble occurred when the parts were assembled.

Fig. 2—Motor-generator sets which furnish the power supply for the motors shown in Fig. 1.

In the original installation the right-hand motor-generator set supplied the roughing-mill motor and the left-hand set (only part of it can be seen) supplied the finishing-mill motor. In the final installation these two sets were used to supply the roughing-stand motors only. Notice that the flywheels have been removed. The exciter set has been mounted over a part of the space where the flywheel was in the right-hand set.



When the first trial of the drive was made, the motors "would not pull your hat off" to use a phrase sometimes applied to a balky horse. Breakers were blown as fast as they could be reset. The circuit-breaker settings were gradually increased until the overload rating of the motors was exceeded, and still the breakers would blow. The motor-generator set would slow down excessively, in spite of the heavy flywheel. The lack of sufficient torque was so apparent as to suggest that something was wrong, either in the wiring or the machine windings. Everything was checked over and over without disclosing anything of importance. Finally, after the machine completely failed to do any work, the manufacturers were notified and they very promptly responded.

Upon the arrival of the manufacturers' engineers the motors were tried again and readings taken. Computations were in order and there was a general mixture of all kinds of mathematics. Slide rules were much in evidence. In desperation, the switches which short circuit the slip regulators were closed, thus running the induction motors driving the motor-generator sets without resistance, and consequently preventing the motors from slowing down so much and doing away with nearly all of the flywheel effect. This, of course, increased the input peaks to the driving motors. The motor-generator sets, however, soon began to show signs of distress and

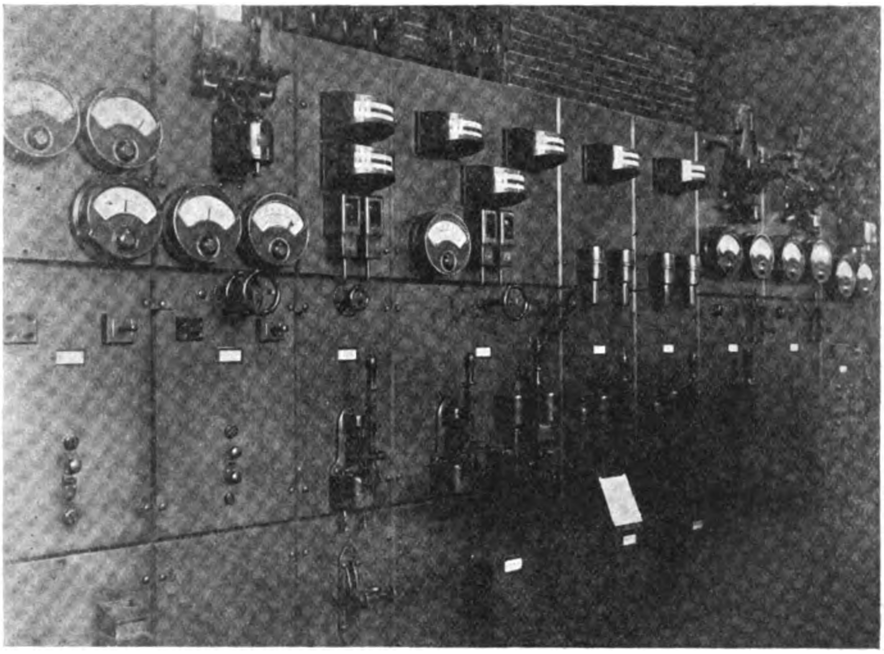


Fig. 3—Switchboard which controls the alternating-current motors driving the three motor-generator sets and the main direct-current feeders to the mill driving motors.

it was decided to put one mill motor on two motor-generator sets in parallel, inasmuch as they now seemed to be suffering more than the motors. This was Saturday afternoon. Heavy busbar copper was sawed up, a double-pole double-throw switch was made, the cables were rearranged and the control changed so that first the roughing-mill and then the finishing-mill motor could be put on the two generators of the motor-generator sets running in parallel. This work was done that night. Connections were checked, voltage readings taken at the field terminals and shortly before noon the next day everything was in readiness for the next test.

The next day the sets were started and a bloom was brought out. The overload breakers were set at about 3,000 amp. We rolled the piece but tripped the breakers. The motor generators were not being crowded, hence, entire attention was paid to the motors. The breakers were raised to trip at 3,600 amp., and the rolling continued. At times the current would trip the breakers at this setting. Vicious sparking occurred at the commutators. It was decided to roll in this fashion until larger motors could be obtained. We had been forced to the painful conclusion that the motors were too small.

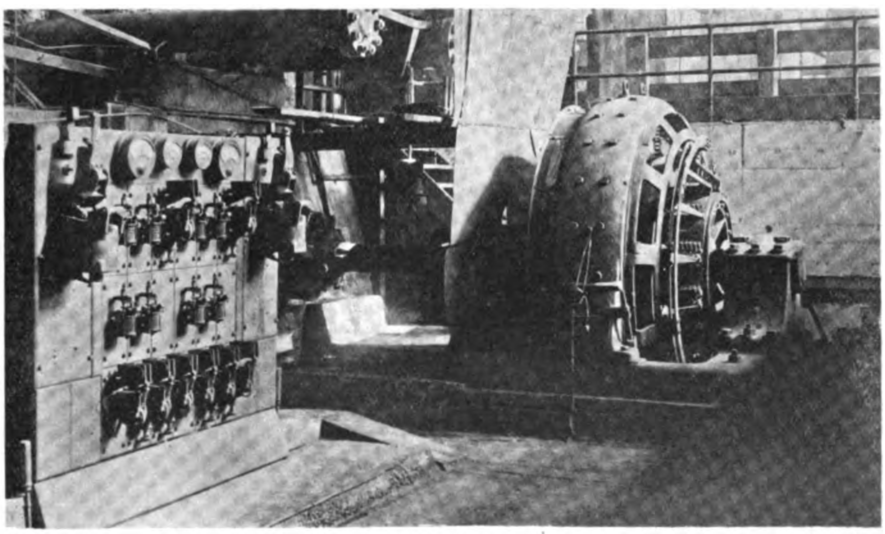
Operations were started that week with depressed spirit. The motors, of course, were heating badly and constant watch was required. The brushes would burn off at the heel, due to the sparking, and had to be ground in every few days. We would cover a portion of the commutator with shellac and sprinkle very fine sand over it and allow it to dry. A few minutes' run of the motor would then grind the brushes to a better fit than could be obtained by hand. The sand was removed by washing with alcohol.

During our discussion of the problem it was agreed that conditions would be improved by reducing the speed of the motor if we could increase the torque in proportion. A reduction gear had been suggested and considered, but for several reasons it seemed to be impracticable. One day it was noticed that the air gap between the pole pieces and the armature of the mill motor was comparatively large, approximately $\frac{3}{16}$ in. It was believed that this could be reduced to about $\frac{3}{32}$ in. without mechanical trouble and that it would reduce the speed and increase the torque for a given armature current. The manufacturer's district engineer was asked for advice and he reported that he could see no objection to doing this. The next week end, soft iron shims were placed under the field poles of the roughing-mill motor, thus reducing the air gap about 50 per cent. Upon starting rolling Monday morning we were delighted to note a very decided improvement and we were deluged with questions from the mill crew as to what we had done over Sunday.

The success of this expedient suggested that it might be possible to still further magnetize the field poles; so it was decided to try a higher voltage on the shunt fields, which were designed for 125 volts and excited by the 10-kw. exciters. The next week end, the shunt fields were connected to our 250-volt. direct-current buses, with an adjustable resistance in series. The field temperature was watched closely and the resistance set to allow the fields to take all the current the windings would stand. Based on the reduction in mill-motor speed with a given applied voltage to the armature, it was estimated that the total increase in torque, obtained by the two expedients, was 25 per cent. It is regrettable that exact values could not be obtained. However, the change was remarkable. Sparking at the commutators was reduced to a negligible amount on the finishing mill, and it was only on the heavier

Fig. 4—This motor drives the finishing stand of the tire mill.

In the foreground is shown the control panel for controlling the field of this motor and also the field of the generator that is shown in Fig. 6.



drafts on the roughing mill that bad sparking still occurred. It now appeared that one motor-generator set would pull each mill, on account of the reduction of the mill-motor speed, so, without advertising the fact, we shut off one motor-generator set.

The mill ran nearly a week on different kinds of work, without any complaint, so it was decided to put each motor on its own motor-generator set. This was done with a material increase in production. Our only trouble now was with the larger drafts on the roughing mill. By taking advantage of everything possible, we were still at times badly overloading the roughing-mill motor. A recording thermometer was used on the hottest place in the system, which was the winding of the induction motor driving the motor-generator set supplying the roughing-mill motor. A green circle was drawn on each chart as a danger line, and the substation operator instructed to lower the voltage delivered to the generator fields, when the temperature approached this danger line. This would reduce the mill-motor speed, but would not affect the torque. The power required of the motor-generator set would be less, which would reduce the current in the driving motor. During these periods of heavy work, we were in constant danger of burning out some of the windings.

Another mill motor was ordered, which was to be a duplicate of those installed, with the exception of a larger armature shaft. This motor was to be coupled directly to the roughing-mill shaft, and the old motor coupled to the new. Before deciding upon the motor-generator set to be ordered with the new motor, several things were considered. Our load cycle was of such character that the load peaks were of too long duration for the size of the flywheels. Short circuiting the slip regulators threw the burden of the peaks directly on the driving motor, and increased the height of the input peaks, but decreased their duration.

This increase in demand was not considered of long enough duration to materially affect the demand meters, which are of 15-min. period. It seemed better to use a somewhat larger driving motor and eliminate the flywheel. If no flywheel were needed, it would be possible to use a synchronous motor with its better power factor.

Increasing the capacity of the drive on the roughing mill about 100% by using two motors connected in tandem on the same shaft as described previously, would place the weakest spot in the whole installation in the driving motor of the motor-generator set supplying the finishing-mill motor. Here was an opportunity to strengthen this point, by connecting the new motor-generator set to the finishing mill and making the driving motor as large as was needed. These changes are shown in the accompanying diagrams. The left diagram of Fig. 5 shows the original installation with the motor-generator sets *A* and *B* supplying the motors *C* and *D* respectively. At the right is the final arrangement with motor-generator sets *A* and *B* supplying the two motors *C* and *F* which now drive the roughing mill only. *F* is a duplicate of *C* except that it has a larger shaft on account of this shaft having to transmit the torque of two motors instead of one. *D* is the old finishing-mill motor and is now driven by the higher capacity synchronous motor-generator set *E*. A larger exciter unit was also necessary, inasmuch as the fields on the finishing-mill motor were able to take more current than the old exciter would supply, so the capacity of this unit was doubled. The following equipment was decided upon:

1—Mill motor: to be duplicate of old motor, except with a larger shaft with extension on both ends.
1—Motor-generator set consisting of:
  1—1100-kva. (720-r.p.m., 2,200-volt synchronous motor.
  1—750-kw., 600-volt, d.c. generator, duplicate of the first generators.
1—25-kw., 125-volt exciter set.
1—Switchboard with synchronous-motor starting and control equipment.
2—3,600-amp., solenoid-operated, air circuit breakers, with remote control.
Several meters of larger capacity to replace those supplied with first outfit.

This equipment eventually arrived, and by moving a large motor driving an air compressor, space was made for the new motor-generator set. Installing this unit was a comparatively simple job, as it arrived completely assembled. The base, however, was not strong enough to support the machine without a particu-

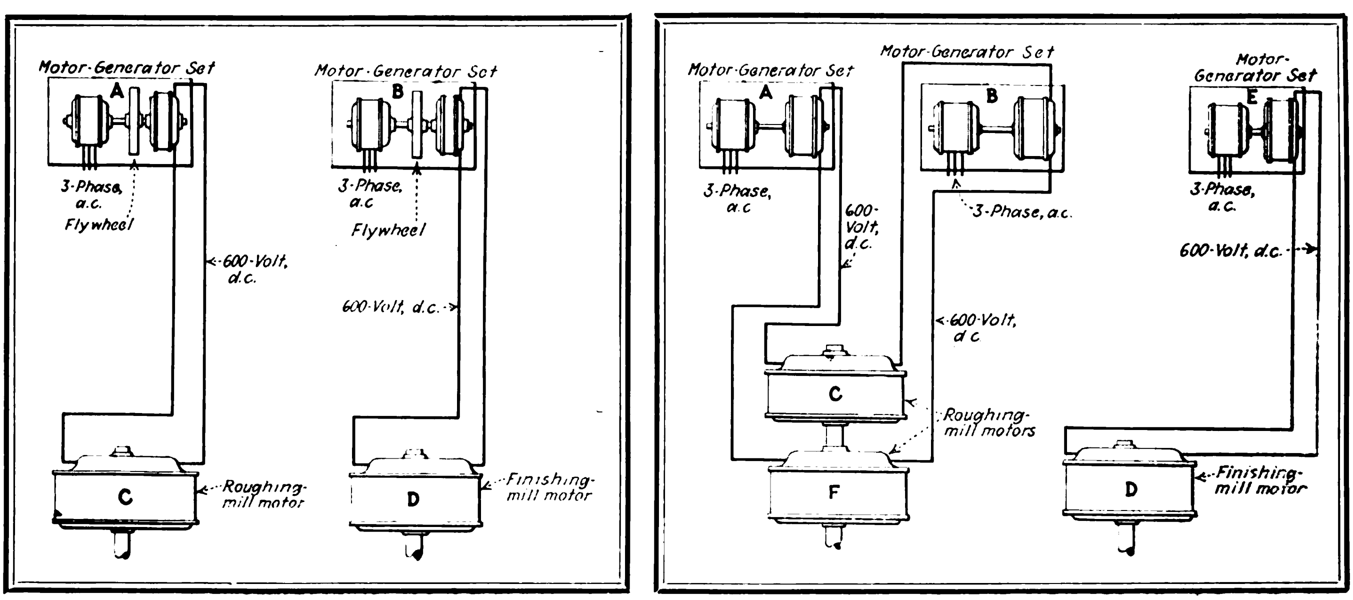


Fig. 5—The changes shown in these diagrams illustrate the flexibility of arrangement that can be obtained with electric drive.
The installation shown at left did not have capacity to drive the roughing and finishing mills. At right the two motor-generator sets *A* and *B* are supplying the roughing-mill motors *C* and *F*. *F* is a duplicate of *C* except that it has a larger shaft. The finishing mill is driven by the same motor *D* but this motor is now supplied from a higher capacity, synchronous motor-generator set *E* which was installed later.

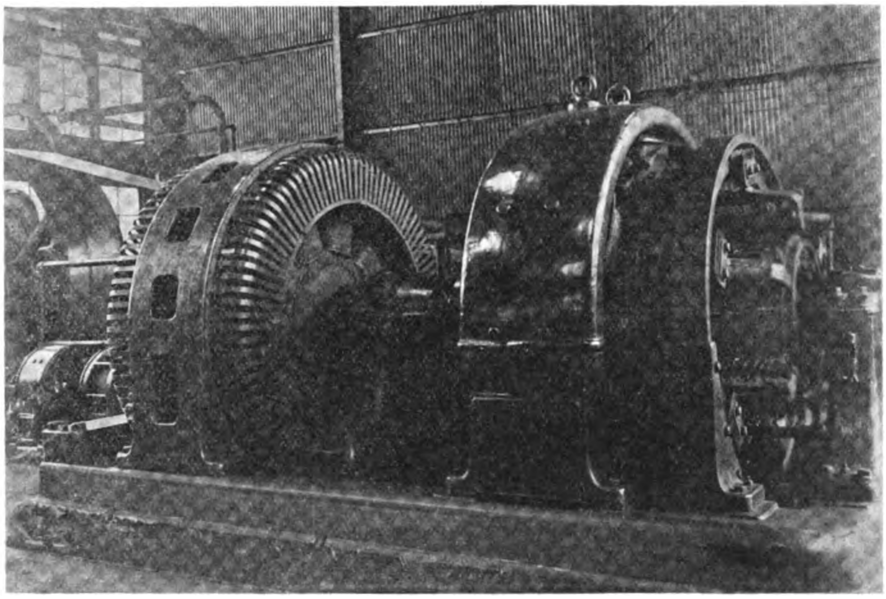


Fig. 6—Synchronous motor-generator set for supplying power to the finishing-mill motor shown in Fig. 4.

This set was the one that was added to the original installation. Since no need was found for the flywheels in the original motor-generator sets, they were omitted from this set and this permitted the use of a synchronous motor instead of a wound-rotor induction motor. An exciter set is shown in the background at the left.

lar arrangement of wedges under it. The bolts in the coupling were loosened and the base deflection was indicated by the distance between different points on the coupling flanges. The wedges were adjusted until the coupling faces were parallel and then the base was grouted in. How well the units line up is shown by the fact that only a slight pressure on the end of the shaft when the machine is running, is enough to set the armature into lateral oscillation. Fig. 6 shows the new motor-generator set. The motor was removed from the foundation in the roughing mill and the new motor with the large shaft installed in its place. The old motor was then connected up direct in line, and coupled to the new motor by a "Fast Flexible Coupling."

The method used in lining up the two motors was as follows: The mill shaft bearings were first put in good repair; then a line was run from a point on the center of the front end of the mill shaft, through a similar point on the back end of the mill shaft, and across the building containing the motors. A steel binding wire was stretched tightly across mill and motors on this line, and plumb bobs were dropped to center punch marks on the shafts of the mill and motor. This gave the correct line up in a horizontal plane. The level or line up in a vertical plane, was obtained by the use of a surveyor's level. An additional check was made at the coupling flanges which were found to coincide exactly. The two old motor-generator sets were to supply the direct-current power to this two-motor combination. The cables were arranged so that the voltage between units, was kept down to the voltage of one set by connecting the motors and generators alternately in series as shown at the right of Fig. 5. Fig. 1 shows the new arrangement of two motors in tandem.

The reserve capacity of the roughing-mill drive now made it possible to use the small 125-volt exciters furnished with the original equipment, on the motor fields of roughing-mill drive, instead of the higher voltage we had used as an expedient. These two exciter generators were connected in series, which provided a three-wire d. c. system with 250 and 125 volts available. A tap was taken off the 125-volt bus, for operating the magnetic contactors which control the main generator fields, and to supply two contactors which are arranged to insert a fixed resistance in series with the mill-motor fields, when the motors are idle. The shunt fields of the two roughing-mill motors were connected in series, supplied with 250 volts from the exciter system described above, and controlled by the master controller in the pulpit of the roughing mill.

The fields of the motor-generator sets supplying the roughing-mill motors are controlled from the master controller mentioned. On account of the greater inductance of this circuit it was necessary to replace the blow-out coil on the generator-field contactor, with one having a greater number of turns, in order to properly handle the arc at the contacts.

The new motor-generator set was connected to the finishing-mill motor without any changes in control, except to connect the shunt fields and the generator fields of the motor-generator set, to the new 25-hp., 125-volt exciter. The weakest place in the whole system is now the armature of finishing-mill motor, but on account of the drafts on the finishing mill being lighter, this motor is not overloaded.

The flywheels on the old motor-generator sets were now quite generally regarded as a nuisance. It was evident that the induction motors on the motor-generator sets would easily furnish power for the peaks, without trouble, and apparently at no disadvantage. With the flywheels it took some time to start the sets, and as they would run from 90 to 125 minutes after shutting off the power, it was not possible to give them any attention over noon periods or between shifts. At one time a shorted generator coil could have been prevented, by stopping the set and cleaning out the burning dirt under a band, but it was not possible to stop the outfit quick enough. We decided to get rid of them. The manufacturer was asked for advice and agreed that for our conditions we would be better off without them. We could not find a buyer for them, so we cut them from the shafts by the oxy-acetylene process. They were 12 ft. in diameter, and 10 in. thick. We built a shanty around the wheel to protect the electrical machinery and at an expense of three days' labor for the cutter and helper, 32 tanks of oxygen, and about 6 tanks of carbo-hydrogen we removed one wheel. Later we removed the other.

This resulted in a saving of power, reduction of weight on the floor, and also quite a saving of space, due to the removal of the flywheel casing and the mounting of the exciters on the flywheel base as shown in Fig. 2. A considerable amount of power is lost from a high-speed flywheel due to windage, and this power was saved. It may seem that a greater power saving would result from removing the 12½-ton weight from the bearings, but such was not the case, as is proven by the fact that the center bearings ran as warm as before *(Continued on page 457)*

Step-by-Step Methods of

Laying Out Motor Wave Windings

With Schematic Diagrams of All the Steps and Winding Diagrams Showing An Induction Motor Winding at Different Stages of the Job

By A. C. ROE

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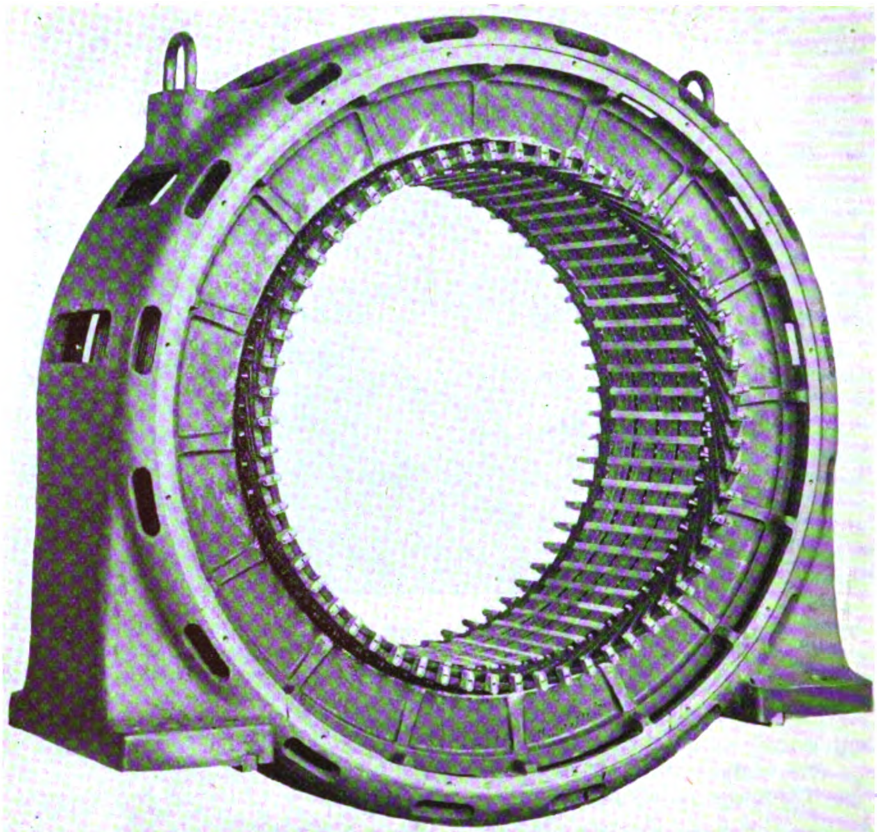


This stator is wound with a two-layer wave winding.

The machine is rated at 125 kva., 250 volts, 720 r.p.m., 60 cycles, three-phase and is manufactured by the Burke Electric Company of Erie, Pa. It has ten poles and sixty slots. It is wound with what are termed half coils, that is, there are sixty bottom coils and sixty top coils connected into one-turn coils by the clips that are shown at the ends of the coils.

THE STATORS of two-and-three-phase induction motors are quite often wound with what is called a wave winding. In a wave winding, correspondingly placed conductors under adjacent poles are connected in series, the circuit proceeding from pole to pole one or more times around the core, and not forward and back upon itself as in a lap winding. The circuits are then interconnected in such a manner as to give the requisite phase relation. The total number of these circuits must be a multiple of the number of phases and is ordinarily twice the number of phases. A wave-connected or wave winding is also defined as one wherein the armature circuit, after leaving a certain coil group, re-enters that coil group after it has passed through at least one other coil group of the winding.

The definitions just given apply to wave windings as used in alternating-current motors. This winding should not be confused with the same winding used in direct-current machines. The direct-current wave winding is sometimes called a two-circuit winding, whereas, in the alternating-current wave winding commonly used, there are two circuits per phase, but each phase in a two-layer winding consists of two sections, that is, a two-phase winding would have four sections and a three-phase winding would have six sections. These sections can be connected in series and if each section has an equal number of coils, the two sections per phase can be connected in parallel. With the alternating-current wave winding, only a series and a two-parallel connection is possible, regardless of the number of poles, although in some cases where there are two or more coils per cell, the total turns can be reduced and the cross section of the copper increased by putting the coils in the same cell in parallel. This is explained later in this article.

THIS is the first of a series of articles on alternating-current wave windings. Wave windings are used in the stators of two- and three-phase induction motors and also on the rotors of wound-rotor induction motors. This article gives step-by-step methods of laying out a wave winding for the stator of an induction motor. Succeeding articles will give short-cut methods and tabulations of data for use in laying out this type of winding and also methods of checking up the accuracy of the layout.

The wave winding as applied to the stators of induction machines must be electrically balanced, that is, each phase should contain a like number of coils or turns. Then, in order to have an equal number of coils in each phase and section, the number of active slots must be a multiple of the number of poles times the number of phases. For example, the number of slots for a four-pole, three-phase, two-layer winding would have to be 12, 24, 36, 48, 60, 72, 84, 96, etc.

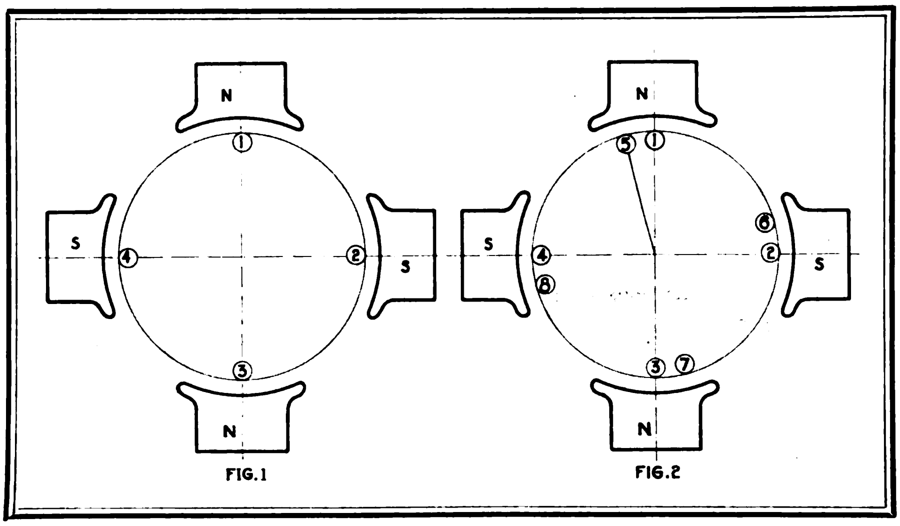
The wave winding as used in alternating-current machines is always made up of strap or bar copper coils using the modern two-layer winding with diamond-shaped coils, or the one bar per slot and involute and connector type of winding. The illustration on page 429 shows a one-turn, strap-copper coil used in a wave winding, and the illustration at the top of this page shows a wave-wound stator.

The alternating-current wave winding is comparatively simple

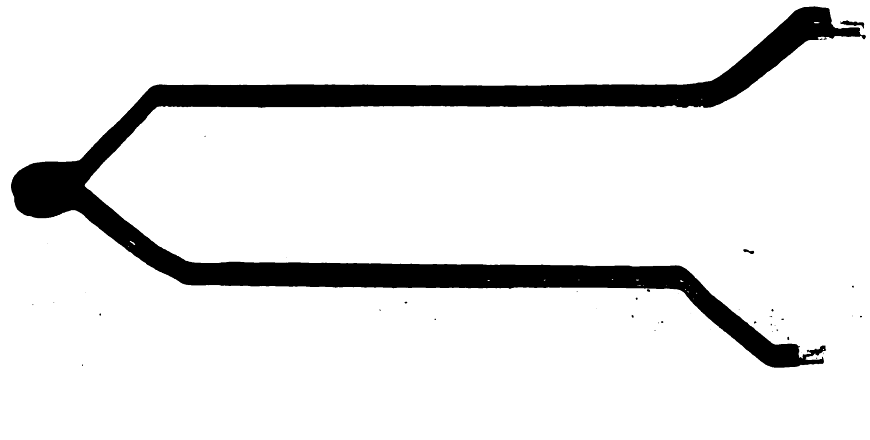
once its principles are understood. In fact, quite often a connection diagram is unnecessary when working on these windings, providing that the number of slots, poles and phases is known.

METHOD OF FORMING A SERIES OF COILS

In Fig. 1 are shown four poles spaced 90 mechanical degrees apart, that is, there are 90 degrees between the center line of one pole and the center line of the adjacent pole. Under the center of each pole is a small circle that represents a conductor on the armature, the conductors being numbered *1, 2, 3, and 4*. In Fig. 2, four additional conductors are introduced, the electrical spacing between the conductors we will assume as being 30 electrical degrees. The fundamental principle of the wave winding is that all conductors that are at the same potential at any given instant, are to be connected in series. Therefore, in a four-pole machine, there will be four such points, six in a six-pole machine, eight in an eight-pole machine, etc. In Fig. 1, conductors *1, 2, 3*, and *4* occupy the same relative position, that is, each is directly under the center of a pole, and disregarding any irregularities in the air gap, each conductor will be at the same potential. The direction of flow of current, however, is not the same. for conductors *1* and *3* are in a field of polarity opposite to that in which conductors *2* and *4* are located. This is shown by the arrows in Fig. 3. For a current to flow, there must be provided a closed circuit. This is done in Fig. 3, by starting at the front end of conductor *1* and attaching a lead, A, as is shown by the dotted line. The back of conductor *1* is connected to the back of a conductor exactly one pole pitch away, either to the right or to the left. In Fig. 3, the full line connects the backs of conductors *1* and *2*. The front of conductor *2* must be connected to the front of a conductor one pole pitch away in the direction first started, hence, the front ends of conductors *2* and *3* are connected as shown by the dotted lines between the two conductors. The back of conductor *3* must be connected to the back end of a conductor one pole pitch ahead as shown by the full line. A lead is attached to the front end of the last conductor and it is brought over to and almost touching the lead from conductor *1*. If these two leads were connected together, a closed circuit would be formed and a current would flow. The circuit just completed forms what is termed a series of coils and is one of the distinguishing features of a wave winding.



Figs. 1 and 2—The small circles under each phase represent conductors on the armature.
Conductors *1, 2, 3*, and *4*, occupy the same relative positions on the armature, hence each conductor will be of the same potential at the same instant.



Diamond-shape coil for use in a wave winding.
Although this is a one-turn coil for a two-layer winding having four conductors per slot it is practically the equivalent of a two-turn coil, for the first series of coils around the winding connects the outside straps of each coil and on the second time around the armature the inside straps are connected in series with the outside straps. Consequently each coil is passed through twice. To reduce the number of turns by one-half, this coil can be made the equivalent of a one-turn coil by connecting the two straps in parallel.

The front and rear connections to conductors *1* and *2* form a coil, likewise, the front and rear connections to conductors *3* and *4* form a second coil, the two making a series of two coils. Therefore, in any wave winding there will be such a series of coils and the number of coils in series will be equal in all cases to one-half the number of poles in the winding. For example, there are two coils in a four-pole machine, three coils in a six-pole machine, four in an eight-pole machine, etc. Now, instead of having the series of coils ending on itself, as shown in Fig. 3, the end of the first series of coils could be connected to the start of a second series of coils if additional conductors were provided. In Fig. 2 conductors *5, 6, 7* and *8* are all in the same relative position to each other and are at the same potential, but are not in phase with or at the same potential as conductors *1, 2, 3*, and *4*. Conductors *5, 6, 7*, and *8* can be connected in series as was done above and this series of coils could be connected in series with, but never in parallel with, the first series.

A little explanation of the statement that two or more series of coils should not be connected in parallel will not be amiss. This also applies to the paralleling of the coils in any one pole-phase group in a lap winding. It was stated above that conductors *1* and *5* are 30 electrical degrees apart. The same is true of conductors *2* and *6*, *3* and *7* and *4* and *8*. Hence, as the magnetic field of an induction motor follows a sine curve, it follows that conductor *5* does not reach its maximum or minimum value at the same instant as

conductor *1*. Also, the two conductors are not in phase, in other words, conductor *1* would at any instant have a higher or lower potential induced in it than conductor *5*. The same is true of conductors *2* and *6*, *3* and *7*, and *4* and *8*. If the two sections of coils in a wave winding, or the two adjacent coils in a pole-phase group of a lap winding, were put in parallel, the series of conductors *1*, *2*, *3*, and *4* would be at a higher or lower potential than the series of conductors *5*, *6*, *7*, and *8*. This difference of potential would set up circulating currents and cause heating. This also explains why it is impossible to parallel the conductors in one slot with those in an adjacent slot. As an example, assume that there are 120 conductors in forty slots, or three per slot, and that it is desired to reduce the number of turns or conductors one-half by paralleling two conductors of adjacent slots. These two conductors would be out of phase an amount equal to the electrical angle between the adjacent slots. This would be the greater the less the number of slots.

In Fig. 4 is shown the second series of coils connected to the first series. In order to connect these two series of coils together, it was necessary to reduce the pitch between conductors *4* and *5*, that is, the distance between these two conductors is not equal to one complete pole pitch. This is a very important feature of this type of wave winding. It can be stated as a rule that at the end of one series and the beginning of the next, the front pitch must be reduced one slot. When there is more than one conductor per cell, the front pitch in slots is the same, but one strap or conductor less, and the winding is carried around the armature through the same series of slots until all the straps in the cell in the starting slot are used, then the pitch is dropped one slot. This is further explained in the caption to the illustration of a diamond-shape coil on page 429.

There will be as many of these series of coils as there are slots per pole per phase. In a thirty-six-slot, four-pole, three-phase motor, there will be $36 \div 4 = 9$ slots per pole and $9 \div 3 = 3$ slots per pole per phase or three series of two coils.

Figs. 5 and 6 show how the same conductors would be connected in a lap winding. Note how the front connections bend in towards the center of the coils in contrast to Fig. 3, where the front connections bend away from the center of the coil.

Arrangement of Series of Coils to Form Sections

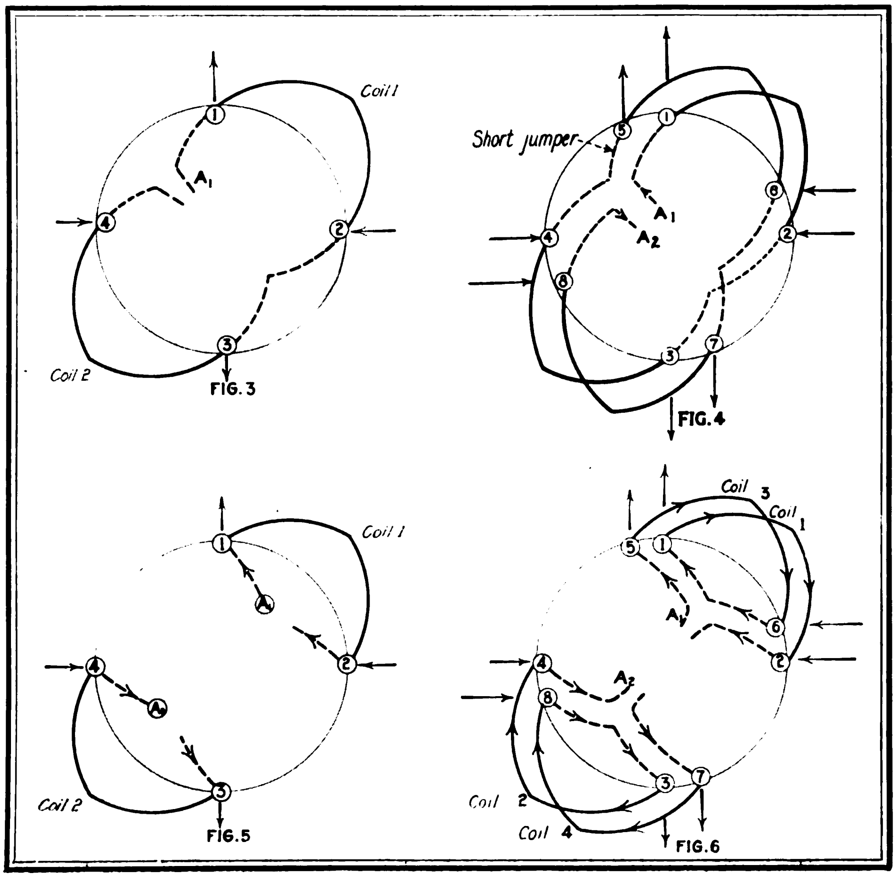
So far we have dealt with only one conductor per slot. This was done to establish the method of connecting the conductors in series. The majority of stators, however, have a two-layer winding or two halves of a coil per slot, that is, a top and a bottom half. In Fig. 7, there are eight conductors or two per slot, these eight conductors forming four coils. In Fig. 7 and the following diagrams the top half of a coil is represented by the full line and the bottom half by the dotted line. The first series of coils consists of conductors *5*, *2*, *7* and *4*. This leaves four conductors unconnected, one in each slot, that is, conductors *6*, *3*, *8* and *1*. In Fig. 8, these last four conductors have been connected in series. Comparing Figs. 7 and 8, it will be noticed that coils *1* and *4* and likewise coils *2* and *3* are 90 mechanical degrees apart. Consequently, we find that in a two-layer winding each phase is divided into two sections of series of coils, the number of series still being equal to the number of slots per pole per phase and the coils per section are equal to one-half the number of coils per phase. Where there is more than one coil per cell, the number of coils per section will be equal in all cases to one-half the slots per phase times the straps per cell, likewise the number of series of coils is equal to the slots per pole per phase multiplied by the number of straps per cell.

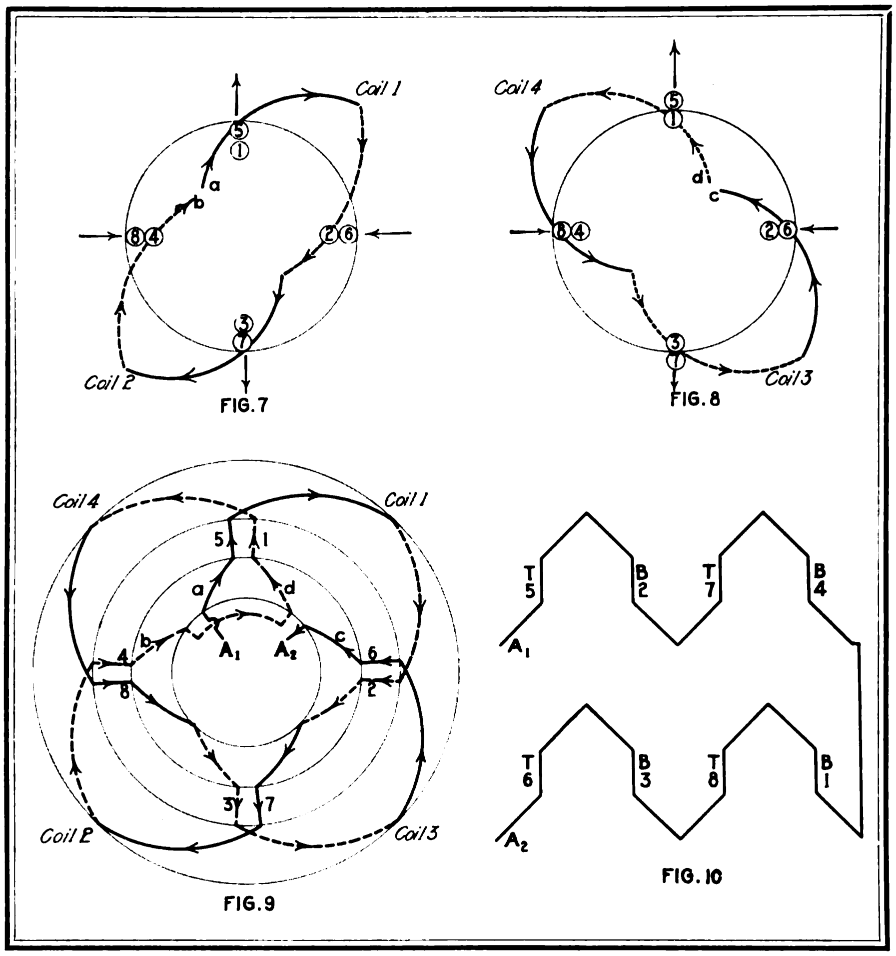
For a winding having 96 slots and 8 poles the number of coils per phase equals $96 \div 3 = 32$. The number of coils in a series equals one-half of the total number of poles equals $8 \div 2$ or four coils in a series. The number of series per section equals the number of slots per pole per phase equals $(96 \div 8) \div 3 = 4$. Hence there will be four series of four coils per section.

The two sections of any one phase in a two-layer winding are formed as follows: In each slot there are two coil halves or coil sides, a top half and a bottom half. A coil is composed of a top half in one slot and a bottom half in a slot one pole pitch away. Hence when one section of a series of coils is completed there remains an unused coil half in each

Figs. 3 to 6—Method of connecting conductors in series in a wave winding.

A fundamental principle of this type of winding is that all conductors that are at the same potential at any instant are to be connected in series. Figs. 3 and 4 show the connections for a wave winding, while Figs. 5 and 6 show the connections for a lap winding.





Figs. 7 to 10—Method of arranging coils to form sections and phases. Fig. 7 shows one section and Fig. 8 shows another. Fig. 9 shows the connection of the two sections to form a phase. Fig. 10 shows a developed view of the phase.

slot passed through. When the first section uses a top half in one slot and connects across the rear to a bottom coil half in a second slot, the second section will use the top half in the second slot and connect across the front to the bottom coil half in the first slot.

Method of Connecting Sections to Form a Phase

After connecting the series of coils into sections as is shown in Figs. 7 and 8, the next step is to connect these sections of series of coils in series to form one complete phase. In Fig. 7, we have a top lead *a* and a bottom lead, *b;* these two leads form the start and finish of one section. In Fig. 8, there are two similar leads, a top lead *c* and a bottom lead *d*, which form the start and finish of the other section. This brings out another feature of this type of winding: namely, there will be twice as many sections as there are phases and also that each phase will have two sections and four leads, two of the leads being top leads and the other two being bottom leads. The leads to the star connection must be either all top or all bottom leads. In this case, we will take the top leads for the line leads, as *a* of Fig. 7. Then the bottom lead *b* of this section must connect to the bottom lead *d* of the next section in such a manner that the polarity is correct. This is accomplished by connecting the bottom leads *b* and *d*, as is shown in Fig. 9. The connection between the bottom leads *b* and *d* is termed the reversing jumper. In Fig. 9, the starting lead *a* which is also the starting lead of the phase is marked A_1. Starting with A_1, we go through coil *1* in a clock-wise direction to coil *2*, then out on the reversing jumper to coil *4*, through this coil in a counter clock-wise direction to coil *3*, and out on lead *c* which is the finish of the section and also of the phase. It is marked A_2. Fig. 10 shows the developed view of the two sections of coils. In this diagram, the coils marked *T* are top coils and those marked *B* are bottom coils. The numbers beneath the letters refer to the number of the conductor or coil half. The facts given in the foregoing discussion can be summarized in the following rules:

Rule 1—The number of coils in a series is equal to one-half the number of poles in the winding.

Rule 2—The number of series of coils equals the number of slots per pole per phase, which is equal to the number of slots divided by the number of poles and this result divided by the number of phases.

Rule 3—The number of sections equals twice the number of phases, that is, each phase will have two sections.

Rule 4—The number of coil groups is equal to the number of poles multiplied by the number of phases.

From the foregoing rules and the discussion, we have obtained sufficient information to construct a diagram for a two-layer winding of any number of slots and coils. The coils are arranged in groups while winding, the same as with a lap winding and the first and last coils (phase coils) of each group should be reinforced on the ends with extra insulation. The following data will be required before laying out a winding:

1—Number of slots
2—Number of phases
3—Number of poles
4—Number of coils
5—Number of coils per slot
6—Number of sections
7—Number of coils per section
8—Number of groups
9—Number of coils per group
10—Number of coils per phase
11—Winding pitch
12—Front pitch
13—Back pitch

To illustrate the use of the principles outlined above, we will construct step by step, a diagram for a four-pole, two-phase motor having twenty-four slots and twenty-four coils. Then our winding data will be tabulated as follows:

1—Number of slots—24
2—Number of phases—2
3—Number of poles—4
4—Number of coils—24

The first four items are taken from the data given in the description of the winding in the preceding paragraph.

5—Number of coils per slot = total number of coils ÷ total number of slots = 24 ÷ 24 = 1.

6—The number of sections according to *Rule 3* will be equal to twice the number of phases = 2 × 2 = 4.

7—The number of coils per section = total number of coils ÷ total number of sections = 24 ÷ 4 = 6.

8—The number of groups, according to *Rule 4*, equals the number of phases × the number of poles = 2 × 4 = 8.

9—The number of coils per group = the total number of coils ÷ the total number of groups = 24 ÷ 8 = 3.

10—The number of coils per phase = the total number of coils ÷ the number of phases = 24 ÷ 2 = 12.

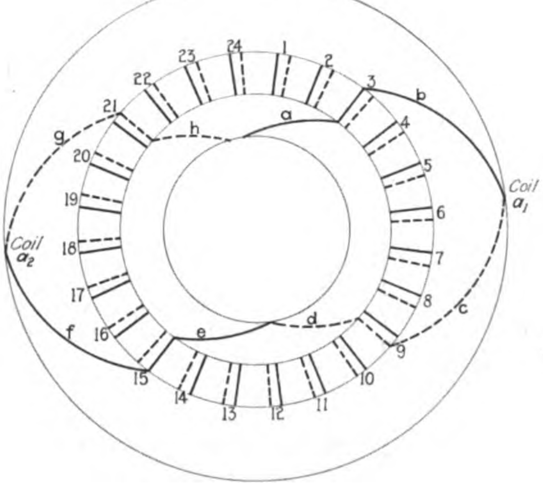


FIG.11

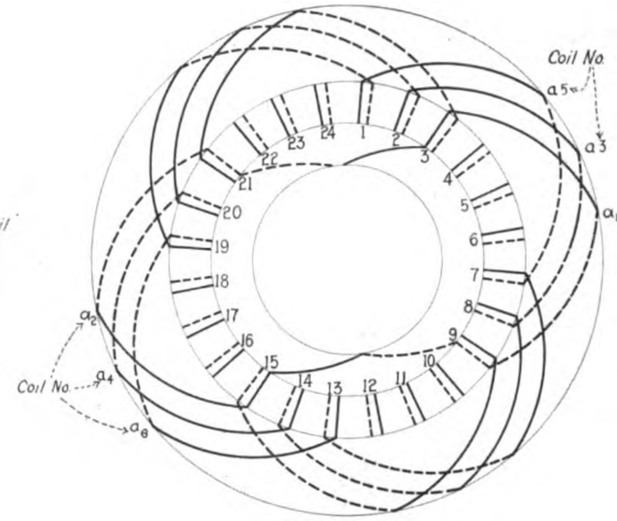


FIG.12

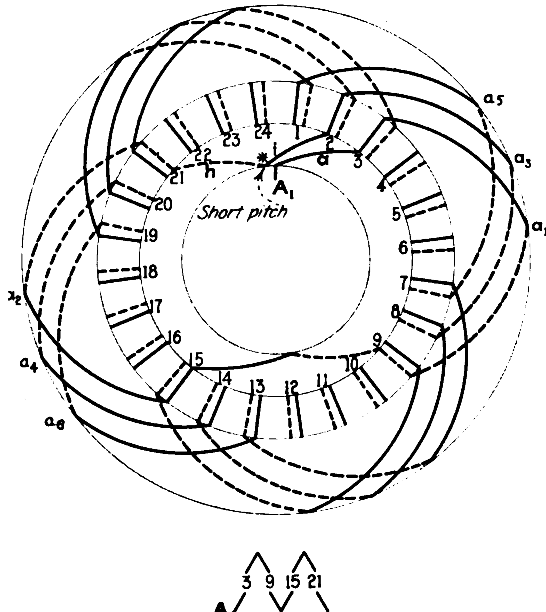


FIG.13

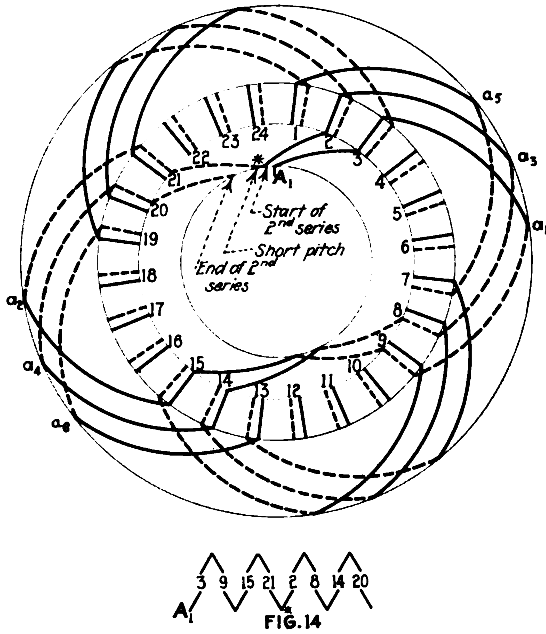


FIG.14

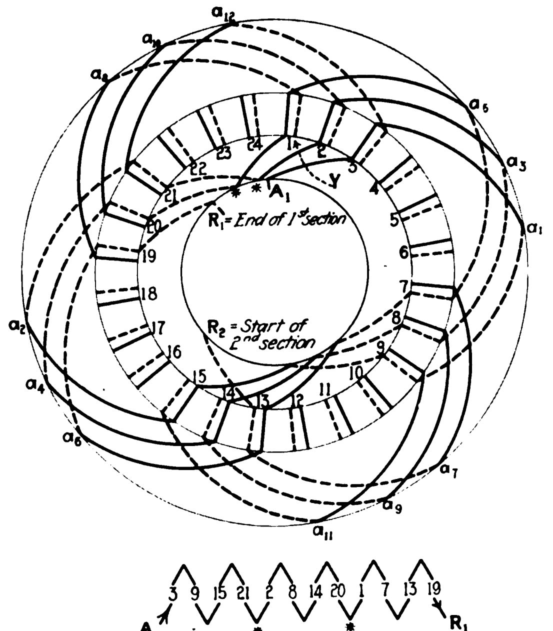


FIG.15

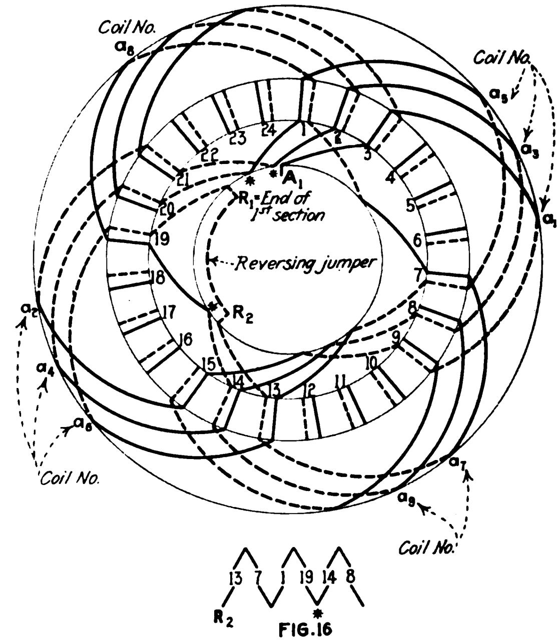


FIG.16

11—The winding pitch = the total number of slots ÷ half the number of poles = 24 ÷ 2 = 12, that is, the total winding pitch will be 1-and-13.

12—The back pitch is equal to one-half the winding pitch = 12 ÷ 2 = 6, which is a pitch of 1-and-7.

13—The front pitch is equal to the winding pitch minus the back pitch = 12 — 6 = 6, which is a pitch of 1-and-7.

The winding resulting from the above data and calculations will be one having two sections of coils per phase, each section consisting of three series of two coils each. Fig. 11 shows the first step in laying out the winding. Four concentric circles are drawn. The slots are laid out between the two inner circles, one full and one dotted line for each slot. The full line in the slot represents the top coil half or top conductor and the dotted line represents the bottom coil half or bottom conductor. The kind of coil used in winding the stator determines whether the winding is right or left. In Fig. 11 a left-hand coil will be used.

The next step is to lay out a series of coils. Select a top coil half or a bottom coil half in any slot. We will choose a top conductor in slot *3* and will draw a full line from the front of the top conductor in this slot to a point on the inside circle equal to one-half the front pitch measured to the left from slot *3*. As was done in the previous diagram the full lines connect to the top coil halves and the dotted lines connect to the bottom coil halves. Next, draw a full line *b* from the back of the top conductor in slot *3* to a point on the outer circle equal to one-half the back pitch measured to the right from slot *3*. That is, count in a clockwise direction from a point on the outer circle opposite slot *3*, a distance equal to one-half of 6 or 3, which brings us to a point opposite slot *6*.

As has been stated before, this point on the outer circle is to be connected by a full line *b* to the back of the top conductor in slot *3*. It is also to be connected by a dotted line *c* to the back of the bottom conductor in the slot one full back pitch away from the starting slot. Counting in a clockwise direction from slot *3*, a distance equal to the back pitch, which is 6 slots, we arrive at slot *9*. From the front of the bottom conductor in slot *9*, draw a dotted line *d* to a point on the inner circle which is one-half the front pitch ahead of slot *9*. One-half the front pitch is equal to 3; counting 3 slots in a clockwise direction from slot *9* we will arrive at slot *12*. The dotted line *d* is to connect the bottom conductor in slot *9* with a point on the inner circle opposite slot *12*. This completes the first coil which we will call *a1*. The *a* signifies that it is in phase *a* and the *1* signifies that it is the first coil of that phase.

Next connect line *d* to front of conductor in the top of the slot which is one front pitch away from slot *9*. Counting from slot *9* in a clockwise direction, a distance of one front pitch or 6 slots, we arrive at slot *15*. The connection between line *d* and the top coil in slot *15* is made by the full line *e*. This starts the second coil of the series. Connect the back of the top conductor in slot *15* to the back of the bottom conductor in a slot which is one back pitch measured in a clockwise direction from slot *15*. Counting six slots in a clockwise direction from slot *15* we arrive at slot *21*. This connection is shown in Fig. 11 by the full and dotted lines *f* and *g*. Next draw the dotted line *h* from the front of the bottom conductor in slot *21* to a point on the inner circle equal to one-half the front pitch measured in a clockwise direction from slot *21*. Do not join this line to the full line *a* but leave a small space as is shown in Fig. 11. This completes coil *a2* and it also completes the first series of coils. For the series to be correct, we should be able to count a number of slots equal to the front pitch from slot *21* in a clockwise direction and arrive at the slot from which we started the series. Counting from slot *21* in a clockwise direction, a distance equal to six slots, we arrive at slot *3*, which is the starting slot for the series and this proves that so far the winding is correct.

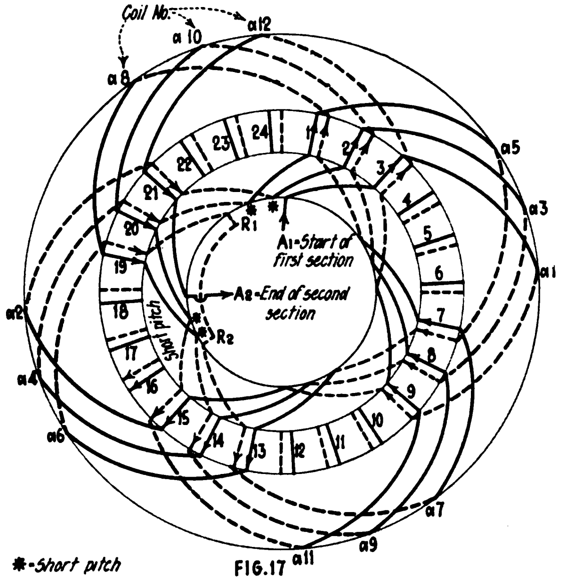
The next step is to draw in all the back connections for one phase, as is shown in Fig. 12. We know that there are three coils per group and twelve coils per phase and also that there are two sections of six coils per section per phase. We have located two coils; the next problem is to find out which side of slot *3* the other two slots of the same phase and pole will follow. Since this type of winding is always retrogressive, the beginning of the second series is to the left of the slot that the first series started in when using a left-hand coil, and when using a right-hand coil, the second series will start in the slot to the right of the one the first series started in. As this winding is being wound with left-hand coils, the slots to the left of those used by the first series are the ones that are used, hence in Figs. 11 and 12 slots *2, 1, 8, 7, 14, 13, 20* and *19* are the other slots of this series. We then join the top coil sides in slots *1, 2, 13*, and *14* to the bottom coil sides of slots *7, 8, 19* and *20* respectively. This gives us coils *a1, a2, a3, a4, a5*, and *a6*. The other five coils are formed by joining the top coil halves in slots *7, 8, 9, 19, 20* and *21* to the bottom coil halves in slots *13, 14, 15, 1, 2*, and *3* respectively. This forms the twelve coils for one phase.

Fig. 13 shows how the second series of coils is started. As was explained previously, the dotted line *h* from the front end of the bottom conductor in slot *21* is not brought over a distance equal to one-half the front pitch, but is brought over a distance on the inner circle equal to one-half of the short pitch as used previously. This point on the inner circle is marked with an asterisk in Fig. 13. This point is connected by a full line to the top conductor in slot *2*. The front pitch between these two conductors in slots *21* and *2* is known as a short pitch. In this diagram the starting lead of the first series which connects to the full line *a* is marked A_1. The developed view of the winding from the point A_1 to the place to which it has been completed thus far is shown at the bottom of Fig. 13.

The second series of coils is continued on through slots *2, 8, 14*, and *20* as is shown in Fig. 14. The full pitch of 6 for both the front pitch and back pitch is used for all coils except at the start of the series between slots *21* and *2* as was spoken of before. At the bottom of Fig. 14 is shown the developed view of the winding as it has been carried thus far.

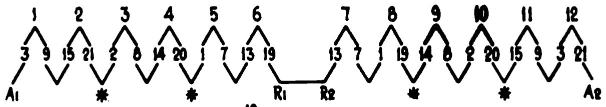
To start the third series between slots *20* and *1*, the short pitch of 5 must again be used. This is shown in Fig. 15 and is indicated by the second asterisk. In this figure the third series of coils has been drawn in complete. This completes the first section. As can be seen, the first section consists of six coils made up of three series of two coils each in series. There are two short pitches as is marked by the asterisks. This brings us to another important rule of this type of wave winding.

Rule 5—Between the starting and finishing leads of each section there will occur a number of short pitches



*-Short pitch

FIG.17



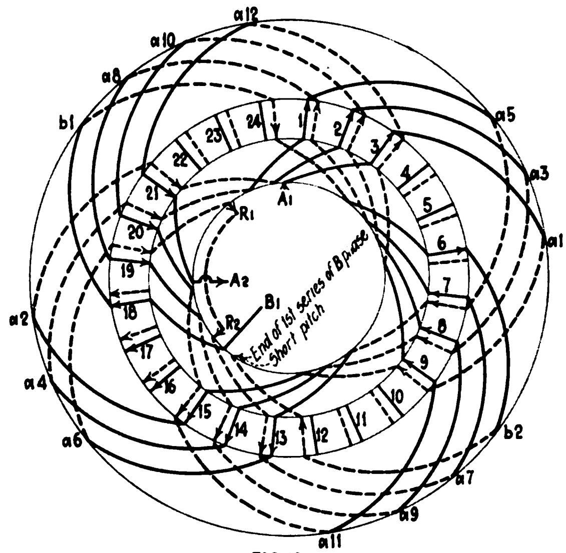


FIG.18

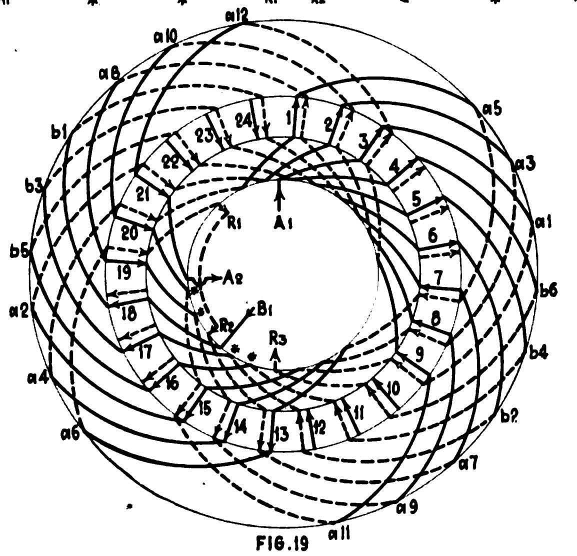
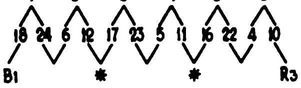


FIG.19



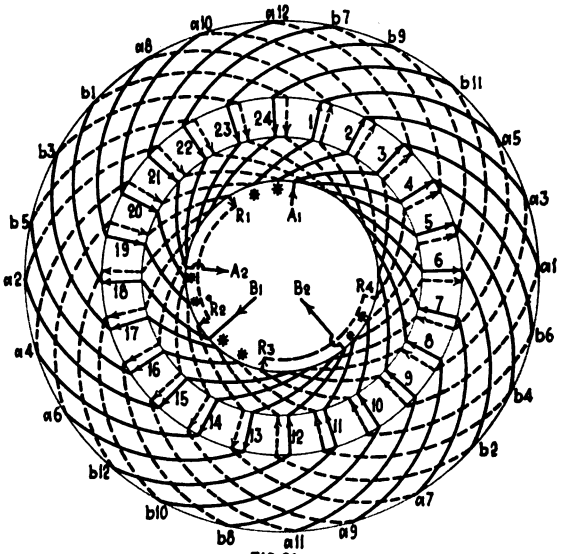
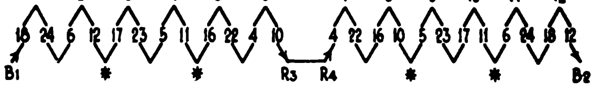


FIG.20



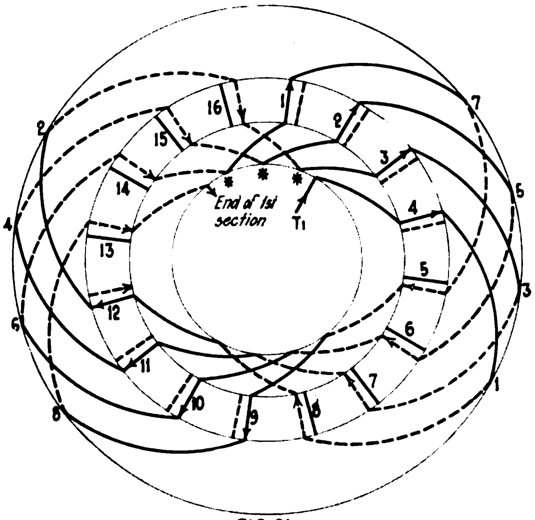


FIG.21

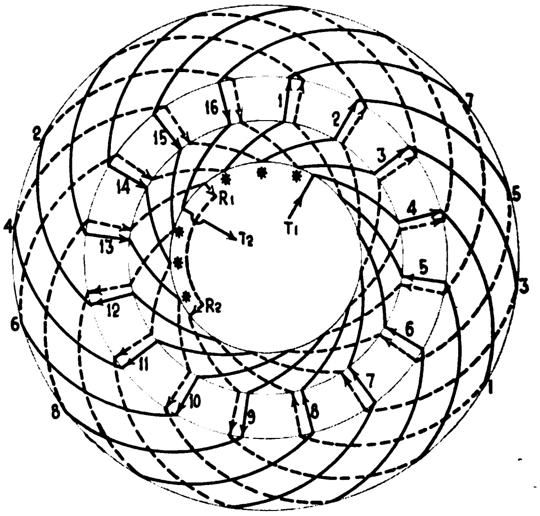


FIG.22

equal to one less than the number of slots per pole per phase.

In the winding being laid out, there are twenty-four slots, four poles and two phases, hence the number of slots per pole per phase $= (24 \div 4) \div 2 = 3$. According to *Rule 5*, there should be a number of short pitches in each section equal to one less than the number just arrived at, that is, $3 - 1 = 2$ short pitches per section. As can be seen in Fig. 15 there are only two short pitches for the first section, which bears out the conclusion arrived at in *Rule 5*. Notice that in this rule the word slots is used and not coils. The reason for this distinction is that when there is more than one coil or strap per cell, a slot is not dropped until all the straps or coils in the first cell are passed through.

When top conductors are used for leads, the bottom leads of each phase section will form the reversing jumpers or vice versa. The end of the first section will form one reversing jumper lead and the starting lead of the second section of the same phase will form the other reversing jumper lead. In Fig. 15, A_1 is the start of the first phase and section, and is the phase lead. In this same figure the bottom lead R_1 is the end of the first section and is the reversing jumper lead. At the bottom of Fig. 15 is shown a developed view of the first section.

The next step is to start the first series of coils of the second section of this same phase. As was explained before, the coils in a wave winding are full winding pitch, hence the phases or phase belts do not overlap, and when there are an equal number of coils in each section, the coils in both sections of the same phase lie in the same slot. In any slot, there are two halves of two coils, a bottom half and a top half, and when the coil side of the first section uses one-half the slot, the remaining half belongs to the second section. To locate the start of the second section, count either back or ahead one full front pitch from the slot in which the first section ended in. If the first section ended with a bottom conductor, then the start of the next section will also be on a bottom conductor. If the end of the first section was a top conductor, the start of the second will be a top conductor. Never connect a top conductor to a bottom conductor in a series wave winding. While it is possible to pick up the starting lead of the second section in the direction ahead of the finish of the first section, it is most always picked up to the rear or in a direction opposite to that in which the finishing lead bends. This is done for mechanical reasons as there is less crossing of leads with this manner of pick up. In Fig. 15 the first section ends in slot *19* at R_1. Counting in the opposite direction from the way the finishing lead R_1 bends, a distance of one front pitch, which is six slots, we arrive at slot *13*. From R_2 a dotted line is drawn to the bottom conductor of slot *13*, as is shown in Fig. 15. The start of this section could also have been made at Y in slot *1*, which is six slots ahead of slot *19*, but as explained previously, for mechanical reasons the start is made in slot *13*.

Fig. 16 shows the reversing jumper connecting the two bottom leads R_1 and R_2. The series passes through coil *a7* in a counter-clockwise direction, that is, we pass around the winding in a direction opposite to that of the first section. At the end of coil *a8*, which is also the end of the first series of the second section, we have to resort to the short front pitch in order to pick up coil *a9* and start the second series of coils.

In Fig. 17, the second section is shown complete. Note that this section of the winding ended in the same slot that the first series of coils of the first section ended in. Also notice that this second section has two short front pitch coils the same as the first section had. These short pitch coils are marked with asterisks. The reason for this short pitch and its location should be thoroughly understood as it is one of the places that trips the average winder. It should be remembered that there will be twice as many points of short pitch as there are phases in the winding and that these places occur between the starting and finishing leads of each section.

This completes the winding of the first phase. If we start at A_1 and follow the arrows, we will trace through the first section and through the second to lead A_2. A developed view of this is shown at the bottom of Fig. 17.

The next step is to start the second phase. In Fig. 17 there are twelve unused slots: namely, slots *4, 5, 6, 10, 11, 12, 16, 17, 18, 22, 23*, and *24*. These slots can be paired with the first-phase slots to form one complete pole group of six slots, for in any winding the slots per pole equal the total number of slots divided by the number of poles, that is, $24 \div 4 = 6$. It is possible to make the polarity of slots *4, 5*, and *6* the same as slots *1, 2*, and *3*, or the polarity of slots *22, 23*, and *24* can be made the same as slots *1, 2*, and *3*. The same holds true for slots *10, 11*, and *12* as well as slots *16, 17* and *18* in relation to slots *13, 14* and *15*. The B_1 lead, that is, the lead from which the second phase starts, must have the arrow pointing into the winding, therefore, it follows that in any four-pole wave winding, there are four places where it is possible to pick up the B_1 or second-phase starting lead, and there are six places in a six-pole winding, eight in an 8-pole, etc. The mechanical arrangement of the leads and reversing jumper is the deciding factor in the final selection of the location for the starting point of the second phase. The points governing the location of this point will be given in the following rules:

Rule 6.—The R_1, R_2 and A_2 leads are on the left of A_1 for a left-hand winding and on the right of A_1 for a right-hand winding. Inspection of Fig. 17 will show the truth of this statement.

Rule 7.—The R_1 lead will fall behind or ahead of the A_1 lead, a number of slots that is equal to the front pitch plus one less than the number of coils per group. Also, if A_1 goes to a top conductor then B_1 will go to a bottom conductor.

Since the number of coils per group equals three, and the front pitch equals six, according to *Rule 7* the R_1 lead will fall behind the A_1 lead, a distance equal to $6+3-1=8$ slots. In Fig. 17 the A_1 lead of the first phase lies in slot *3*. Counting back or in a counter-clockwise direction from slot *3*, a distance equal to eight slots, we arrive at slot *19*. This is the location of the finishing lead of the first section of the second phase. This slot is the location of the conductor connecting to the R_1 lead. Inspection of Fig. 17 will show this to be the case. According to *Rule 7* if the A_1 lead connects to a top conductor the R_1 lead will connect to a bottom conductor. Inspection of Fig. 17 will show that this actually is the case, that is, R_1 lies in the bottom of slot *19*.

Rule 8.—The R_2 lead is connected to a bottom coil half or conductor when R_1 is connected to a bottom conductor and vice versa, and is spaced one front pitch to the left of R_1 for a (Continued on page 458)

Some Practical Distinctions Between

Maintenance and Repairs on Industrial Equipment

With a Maintenance Organization Scheme Suitable For Medium-Size Plants and Suggestions on Method Of Handling the Work of This Department

A CERTAIN AMOUNT of repairs to industrial equipment is necessary and inevitable. Oftentimes, however, repair work is largely a case of locking the barn door after the horse has been stolen, and the necessity for it could have been avoided if the equipment had received the proper attention. In this article Mr. Cockshott emphasizes the importance of maintenance work from the standpoint of reducing repair costs and gives an organization scheme for the maintenance department of small and medium-size industrial plants, with suggestions on how the work can be most effectively handled.

By MAURICE C. COCKSHOTT
Maintenance Engineer, American Trona Company, Trona, California

IN THE organization of a department of any industrial plant for the efficient upkeep and repair of the equipment too much emphasis can not be placed on *maintenance*, as opposed to *repairs*. It is safe to say that a very large percentage of the repairs in a plant where the upkeep is left in the hands of a so-called repair gang might be cut out if closer attention were paid to maintenance.

Let us first consider what maintenance involves. When a new piece of machinery is to be installed, great pains are taken to make sure that it will aid production and pay for itself in a given time. Its duties are carefully planned and thought out—but is sufficient thought given to its care and upkeep? Is the operator instructed as to when and how it should be lubricated? How about proper protection from wet and dust? Are the characteristics of its efficient operation considered from a maintenance point of view? In many cases the problem has not been considered from this point as fully as it might be, as shown by the repair bills. If these are analyzed carefully they will disclose the fact that, in the vital question as to what the machine could produce in dollars and cents, the necessity of careful maintenance has been overlooked.

In many instances constant repairs can be traced to simple lack of care in operation, a situation where an efficient maintenance man could have saved money by timely advice and prompt action before the repair became necessary. As a case in point, in a certain plant where the belt upkeep was high the plant engineer noticed that large quantities of rosin and sticky belt dressings were being drawn from the stockroom. An investigation was made and it was found that all of the operators of belt-driven machinery were using these dressings at the least indication of trouble, rather than call in the repair man. In practically every case where belt trouble had been reported there was found to be work for a machinist. If the equipment had been periodically inspected, there would have been no need for the use of deleterious dressings on the belts and the real defects such as being out of line, and so on, would have been remedied with the expenditure of less money all around. Now, whenever an operator calls for belt dressings, a machinist is sent and by removing the real cause of the trouble the life of the belt is considerably prolonged.

In the case of most industrial plants, the repair and maintenance sections can be merged into one department under a maintenance engineer and function as the maintenance division, having control of all repair and maintenance and also the construction of new equipment, to a large extent. For a plant employing around a thousand men, an organization scheme shown in the chart can be used to combine the above-mentioned sections so that the maximum efficiency can be obtained.

At the head there should be the chief or maintenance engineer, a man having sound, practical knowledge with executive and planning ability and able to foresee ways and means of cutting expenses, checking reports and studying costs of repair and maintenance to the end that savings may be effected by more efficient methods of handling production. The actual supervision of outside work should be in the hands of an assistant who is capable of assuming the position of the chief, in his absence. He should personally supervise all inspection, repair, and similar work in the plant, calling on the other sections of the *Maintenance Division* for assistance as required. He should also make systematic tours of inspection of all equipment, noting the way in which the machines are handled and reporting to the chief what in his opinion is needed in the way of repairs, or improved operating conditions. These would be matters for the maintenance engineer to study and, after thorough and careful investigation, to lay before the head of the department concerned, with his recommendations. Under this assistant would come the foreman pipefitter, the machine shop foreman, the chief electrician and the head carpenter; also the odd men around the plant who may not have a foreman of their own, such as the painters, riggers, and hoist crew, whom he can handle as occasions demand to the best advantage. This method of handling the work has been found to be very successful in the type of plant under review. Taking, for instance, the case of a rigger who is also a good steel man, when no rigging is to be done he can be sent by the assistant engineer to work under the machine shop foreman, who has charge of the steel workers.

The draftsmen should be placed directly under the chief, as should also the instrument man. In an establishment where there are many valuable instruments, it is absolutely necessary to have a man who is responsible for their upkeep and repair; his salary can be saved many times over by efficient watch over this type of equipment.

All orders for new work, in fact all orders pertaining to the division, should pass through the assistant engineer and in the choice of this man the efficient working of the organization will depend to a large extent. He needs to be a man with ideas, resourceful, and at the same time a man who can assimilate the ideas of others, to the end of making the organization pull well as a unit. Each of the foremen in the division should be instructed in the policy of maintenance rather than repairs, and should be made to see that the organization must function as a whole, rather than as a number of petty chiefs who are all out to further their own ends.

The organization scheme shown in the chart has been used with some small changes in a plant that is engaged in a somewhat difficult chemical process, where much of the work is of an experimental nature and the equipment is operated under very extraordinary conditions at times.

In the matter of giving orders for work to be done several schemes were tried but in the end the following routine was adopted and worked out well. In the case of orders for work emanating from another department a written order was given to the maintenance engineer stating what was to be done and the reasons for the work and, if it entailed shutting down important machinery, the time when it could be most easily spared was noted. The orders to do the work were assigned to the section of the *Maintenance Division* concerned and on its completion accepted by the department authorizing the work.

A scheme that works out well is the Trouble Card System. In the case of a machine which needs repairs, the operator or his foreman puts a trouble card with a brief note of what is the matter in a rack kept in the plant office. This card is taken out by the *Maintenance Division* and replaced by one of another color showing the results of the inspection and the estimated time that repairs will take, and is left in the rack as long as the machine is down. When the job is finished a clearance card replaces this one; it gives a short account of the work done, new parts put in, etc., and is accepted by the department for which the work was done as evidence that the equipment is being turned over to them in running order or otherwise. This card should be signed by a responsible representative of that department. These cards are filed and gone over by the department heads, who then have a better chance to know exactly how much work of a maintenance or repair nature any one piece of equipment is needing and whether it is worth more work or has outlasted its usefulness as a producer.

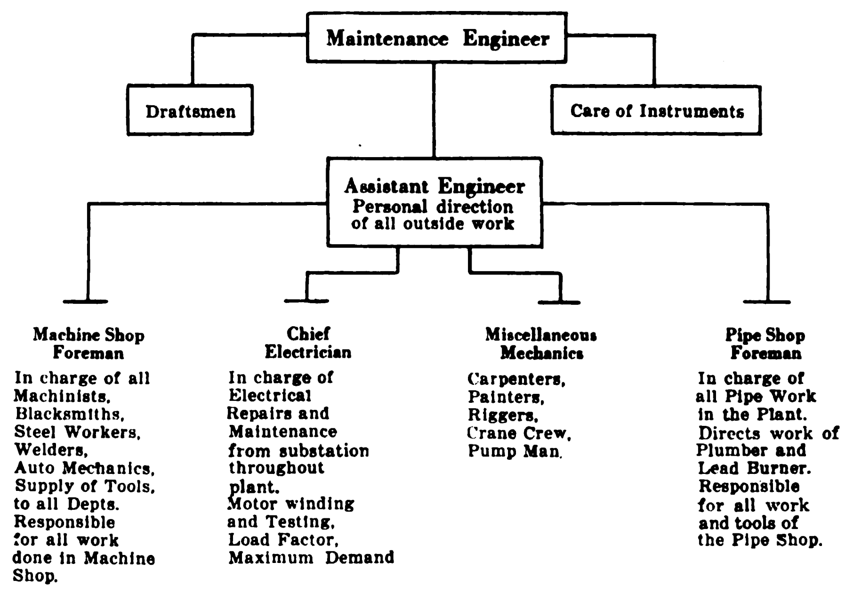
This system is a very valuable source of first-hand information to the maintenance engineer who can follow closely the progress on various jobs. Also, it helps him to decide on the wisdom of keeping the piece of machinery under repair in service beyond its time for the scrap heap, and thus prevents ignorance of its condition becoming an incubus on production costs. In the writer's experience many cases have been brought to light where there was a doubt as to the efficiency of certain pieces of equipment, owing to the inordinate cost of maintenance—or in this case repairs. In the matter of new work or extensive maintenance this is often a question on which higher authority has to be consulted, particularly when the cost is likely to run into a large figure. In such cases the following system might be used.

Assume that the production manager wants extensive changes made in the plant, whereby he figures that a saving can be effected along certain lines. He gives an order for this work to the maintenance engineer, who goes into it in detail and perhaps can suggest ways that are better or more cheaply carried out, and, having agreed with the production manager as to what is to be done, would have drawings made up covering the work in detail. After drawings have been approved, a work order will be made out, if it is desired to have a separate cost kept of the job—and on a job of any magnitude this should always be done. Copies are sent to the accounting branch, the warehouse, and to the assistant engineer with full instructions to the latter as to how the work is to be carried out. On the completion of the job the maintenance engineer will check over the work with the production manager and turn it over to him as completed and, having ascertained that all charges against the work order are in, will have it closed.

Should work be called for which in the opinion of the engineer would not be advantageous from the standpoint of efficiency, he would take it up with the management in a report stating his reasons why the work should not be done, and would not proceed with it until a written order had been given or at least the work modified to better suit conditions. This would have to be diplomatically handled, as at times work is called for with the best intentions in the world but which at the same time is most impracticable from an engineering standpoint.

If the real spirit of Maintenance, as the writer has tried to point it out in this (Continued on page 458)

Organization of the Maintenance Department of a Plant Employing 1000 Men



INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by
G. A. VAN BRUNT F. E GOODING A. J. WHITCOMB

Chicago, September, 1924

Taking a Lesson from Golf

THOSE who have taken lessons in golf have learned the importance of "following through." It is just as necessary for an industrial engineer to follow through in his work of reviving a method or a process. Altogether too often the change stops with the obvious. For example, a new machine may be added to take care of increased production demands. This almost always affects other production units, or at least the auxiliary equipment.

In all of these, the element of material handling is most frequently overlooked. In one case a new machine was added, with double the capacity of the machine then in use. However, as no provisions were made to get the extra material to the machine and away from it, the actual increase in production was only about 15 per cent. In another instance a large boring mill was added to do a job in half the previous time. However, the old "armstrong" method of lifting the parts on and off the machine by the aid of the machinist and helpers was still retained. When an electric hoist was added it not only saved its cost through the elimination of a helper or two, but speeded up the loading and unloading of the machine enough to give it the production output expected.

Many other examples might be given, but these two show what happened when the player did not "follow through."

The Job of the Plant Engineer

SPEAKING of the responsibilities of the Plant Engineer before the Detroit chapter of The Society of Industrial Engineers, H. P. Meredith, General Works Engineer of the Maxwell Motor Corporation described in the following words the duties of this position:

The Plant Engineer, upon full acceptance of his duties, obligations and responsibilities is as essential to industry, if not more so, than most other contemporary positions. His paramount thought is "Production Insurance"; therefore he must of necessity at all times keep his hand on the pulse of his plant and its operations in order that he may ward off interruptions to or the slowing down of production through the failure of plant service, facilities, or equipment. I think I am correct in stating that a decade ago the word "Maintenance" was industrially considered to mean "to fix," and consequently plant service, facilities, and equipment were usually only restored to their effective use after failure had occurred.

He receives large and small orders for every imaginable character of work from all other departments; such orders are, in the majority of cases, in the emergency category and call for immediate attention. As his force cannot be kept up to meet the peak demand, he must, therefore, be conversant with the general operating condition of all other departments, in order that he may have these jobs performed in the order of their priority to the plant's operations as a whole.

The planned work of the Plant Engineer is likely at any time, day or night, Sunday or holiday, to be thrown out of balance or upset through changes of schedule and such calamities as fire, wind, flood, freezing, physical failures of plant service and equipment or through power interruptions, over which he has little or no control whatever. Should any of these vitally affect a part of the plant or the whole of it, the Plant Engineer immediately comes into play, and in such emergencies his ingenuity, tact, and resourcefulness are at once taxed to the utmost. His slogan in such emergencies is, therefore—"Stick with the job until conditions are back to normal."

A large, modern industrial plant with its numerous highly-specialized departments, elaborate planning and scheduling systems, efficient equipment and all the other paraphernalia of present-day production methods, is as delicate and highly organized as a watch. And like a watch it does not take much to throw everything out of gear. A tie-up in one department may affect the schedules of the entire plant.

It is the duty of the Plant Engineer to see that such tie-ups, due to failure of equipment or to other causes, do not occur. If through unforeseen reasons they do occur it is his duty to straighten things out in the best and quickest way and start the wheels turning. His job extends from the bottom of the deepest well, if there is one in the plant, to the tip of the lightning rod on the tallest smokestack, and from boundary line to boundary line. Viewed from any angle, it is a man-sized undertaking.

Remember That Simple Things May Cause Trouble

SOME of the most exasperating troubles around the plant are caused by things that are so simple that trained workmen do not look for them, but pass on to more involved difficulties as being the real causes. The analytical mind starts with one thing at a time, proves or disproves this, and then passes on to another if the first is not the thing sought. By thus eliminating each source of trouble in order, one knows at the end of a search just what was done and what was wrong, as contrasted to the method which pushes and pulls haphazardly and does not know what was the real cause which produced results.

Very often, also, in plant maintenance work, a chance remark by some operator throws the trouble-shooter off the track he would normally pursue if he were to attack the problem unmolested. The operator may report that a motor is heating up because the bearings are dry, and the master mechanic's man may follow up that lead, for he has been sent to locate that unmistakable hot-motor odor and the bearings of this one *are* too warm and the oil level of the reservoirs *is*

down. However, the real cause of the trouble may be that the motor was running for several hours on the resistance. The electrician would have discovered this first off if it had not been for the "tip" from the unskilled man who had done a bit of sleuthing himself.

These examples, and many others like them that every industrial man has experienced all too frequently, emphasize the necessity of a complete and thorough investigation of every trouble. Jumping at conclusions often means an extra call to repeat the repair which frequently has become much more serious, difficult and expensive than if it had been done rightly in the first place.

The Part of the Maintenance Man in Promoting Safety

IT HAS been said that, next to the support of the management, the success of safety work in an industrial plant depends largely upon the attitude and co-operation of the maintenance department. A large part of the activities of this department consist in putting machines into safe condition to operate, in installing safeguards and in other similar work. A maintenance organization thoroughly sold on safety, however, can go much further. If the maintenance workers show by their attitude and example that they believe in safe practices and live up to them, they can go far toward making converts to safety of the workers with whom they become associated in their activities about the shop. If they show an utter disregard of safe practices and express a contempt for the safety idea, their associates are also inclined to adopt the same attitude.

Most maintenance workers go from department to department and, therefore, have the best opportunity to see unsafe conditions and practices and to carry good practices and ideas from one department to another. Also, their training helps them to look for a better way of doing things instead of looking at all obstacles from a "can't be done" viewpoint.

In addition to the examples they set maintenance workers, through mixing with the men in the shop, get the viewpoint of the man on the machine, and if the maintenance worker has the courage of his convictions, he can often set these other men straight where they have obtained an erroneous idea of the reason for safety activities and their value.

Guesswork When Using Belting Is Expensive

BELTS have been used so long as a means of applying power to the drive end of a machine that they are often abused and condemned through sheer lack of common sense in their application and maintenance. R. F. Jones, Research Director for the Leather Belting Exchange Foundation, in a recent article makes these statements:

On preliminary examination a belt as used for power transmission does not appear to be a complicated thing, nor does it seem to involve any problems which cannot be easily solved by the application of mathematics. But upon a more careful and detailed study, certain fundamental phases of the subject are encountered, which present some very puzzling problems. One of these things is the creeping action of the belt on the pulley when each particle of belt undergoes the change of length coincident with its passage from the loose side to the tight side of the belt, or vice versa, when in operation. * * *

Heretofore we have been concerned principally with that form of slippage caused by the elastic give and return of the belt, called **creep.** In addition to this there may be slippage not due to the elastic action which we shall call **true slip.** . . . The load at which true slip begins will vary somewhat with the same belt under various conditions of speed, tension, pulley size, temperature, etc., and it is widely different for belts of different materials, such as friction surface, rubber, and leather. A 4-in. rubber belt running at 3,000 f.p.m. on 24-in. pulleys will carry at average tensions from 10-15 hp. before the advent of true slip, while the same size leather belt may go as high as 30 hp. before this point is reached. No exact method of determining the point where true slip begins is known yet, but it is certain that this has happened, if there is a sudden increase in slip for a small increase in load. A belt under average conditions should not be loaded enough to cause true slip, and the initial tension required to keep the belt within the region of creep ought not to be excessive if long life and service are important. The latest rating charts and tables for leather belting follow this principle.

A great deal of time has been spent by belt manufacturers in developing information relating to the conditions under which a belt will give good service and long life. This information is available at no cost to anyone interested. There is little excuse, therefore, for purchasing belting and applying it on pure guesswork alone or depending on a limited experience with special applications. Operators should be as familiar with belt rating charts and tables as they are with required pulley sizes and speeds, for by correct use of this information actual savings in dollars and cents and freedom from much belt trouble are possible.

What Would a Fire Mean to Your Job?

ANNUAL fire loss in the United States averages over $500,000,000 per year. Much of this is preventable and, like safety, its prevention consists in applying whatever safeguards and precautions are available and in educating the men to be careful. Good housekeeping is important both from an exemplary and educational standpoint and also because many fires have been traced to, or at least helped by, unnecessary accumulations of combustible materials.

Perhaps some of the carelessness is due to the misconception that the insurance company and the industrial plant pay for the losses. However, like taxes, wages, material, and other costs of operation and production, this cost is passed on to the ultimate purchaser in the final price he pays. The insurance company only pays out in a lump, part of the money it gets in the form of insurance premiums from many sources. When an industrial plant has up-to-date fire protection the insurance company recognizes that it is less of a risk and reduces the premium accordingly.

Altogether too often the worker feels that a fire is not *his* loss but that of his employer. However, the employee has no insurance to cover the time required to get a new job or the loss incurred through having to take another at less wages or less desirable in opportunity for advancement or in working conditions. This *whole* loss is his.

To concentrate the attention of all on the national fire loss and how it may be prevented the National Fire Protection Association has indicated Oct. 5 to 11 as Fire Prevention Week. Many industrial plants will observe this. It will pay the worker to consider that fire prevention measures in the factory affect him and remember that they are just as effective and necessary in his home as at the works.

Million-Dollar Iron and Steel Exposition

To be Held in Connection with the Convention of the Iron and Steel Electrical Engineers at Pittsburgh, Pa., September 15 to 20, 1924

PRESIDENT Shoemaker and Business Manager Kelly have set out to make the 1924 Iron and Steel Exposition surpass anything of the kind yet attempted under the auspices of the Association of Iron and Steel Electrical Engineers. This exposition will be held at the Duquesne Garden in Pittsburgh September 15 to 20, and there will be 110 exhibits by leading manufacturers of all kinds of apparatus used in steel mills. In view of the extent and success of the exposition held in Buffalo, N. Y., last year, if the present exhibit exceeds that one it will be the largest and most specialized practical demonstration of steel mill equipment ever shown in this country.

In connection with the Exposition the Association of Iron and Steel Electrical Engineers will hold its 19th annual convention with technical sessions scheduled for Tuesday, Wednesday, Thursday and Friday. The subjects to be discussed at these sessions are as follows:

Association of Iron & Steel Electrical Engineers

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Pittsburgh, Pa.,

August 25, 1924.

TO THE READERS

OF INDUSTRIAL ENGINEER.

The Iron and Steel Industry cordially invites the readers of "THE INDUSTRIAL ENGINEER" to attend the Iron and Steel Exposition, being held at Duquesne Garden, September 15th to 20th, 1924.

You are also welcome to all the Technical Sessions which are being held in connection with the Iron and Steel Exposition, under the Auspices of the Association of Iron and Steel Electrical Engineers.

A special feature which the readers of "THE INDUSTRIAL ENGINEER" will be interested in will be the "ELECTRIC HEATING FURNACE DAY" at which time the design, installation and operation of all types of heating furnaces will be discussed. "ELECTRIC HEATING FURNACE DAY" will be Wednesday, September 17th, 1924.

The Iron and Steel Exposition will be of interest to all engineers in industry. Over one hundred and twenty-five representative manufacturers will offer for your personal inspection and criticism the latest developments in the Electrical, Mechanical and Combustion Arts.

A hearty welcome will be extended to every one.

Yours very truly,

R. S. Shoemaker

President.

TUESDAY MORNING.

9:30 a. m.—Adjustable Speed Sets for Rolling Mills, by L. A. Umansky, General Electric Co., Schenectady, N. Y.

11:00 a. m.—Combustion Control, by E. G. Bailey, Bailey Meter Co., Cleveland, Ohio.

WEDNESDAY—ELECTRIC HEATING FURNACE DAY.

9:30 a. m.—Medium and Low Temperature Applications, by E. A. Hurme, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

10:00 a. m.—Medium Temperature Furnace Installations, by C. F. Cone, The Hagen Corp., Pittsburgh, Pa.

10:30 a. m.—Electric Melting Furnaces, by J. A. Seede, General Electric Co., Schenectady, N. Y.

11:00 a. m.—Electric Heating with Special Reference to Central Stations, by E. D. Sibley, Metropolitan Edison Co., Reading, Pa.

11:30 a. m.—Electric Furnace Installations at the Van Dorn Iron Works, by R. S. Sawdey, Van Dorn Iron Works, Cleveland, Ohio.

THURSDAY MORNING.

9:30 a. m.—Developments in Electric Repair Shop Practice, by A. C. Cummins, Carnegie Steel Co., Duquesne, Pa.

10:30 a. m.—Crane Hoist Travel Limit Devices, by Walter Greenwood, Carnegie Steel Co., Youngstown, Ohio.

11:00 a. m.—The Slagging Producer in Steel Works, by H. K. Huessener, American Heat Economy Bureau, Pittsburgh, Pa.

12:00 m.—Machine Tools and Their Auxiliaries, by John F. Kelly, A. I. & S. E. E., Pittsburgh, Pa.

FRIDAY—CENTRAL STATION DAY.

9:30 a. m.—The Steel Industry and the Electric Utilities, by Merrill Skinner, Duquesne Light Co., Pittsburgh, Pa., and F. D. Mahoney, West Penn Power Co., Pittsburgh, Pa.

Power in the Iron and Steel Industry in America, by Barton R. Shover, Oliver Bldg., Pittsburgh, Pa.

A feature of the practical sessions is the Electric Heating Furnace Day, Wednesday, September 17. As mentioned in the accompanying letter inviting readers of INDUSTRIAL ENGINEER to attend this convention, the problems taken up on Electric Heating Furnace Day will deal with the design and installation of all types of heating furnaces. The papers to be presented will cover the following equipment: Soderberg Electrode; Electrode Regulator; Charging Machines; Multiple Melting Furnace; Regenerator Car-Type Furnace; Double-End, Car-Type Furnace; Rotary-Type Furnace; Continuous Conveyor Furnace; Box-Type Electric Furnace; Vitreous Enameling Furnaces; Comparison Between Furnaces Using Oil and Electric Energy; Muffle-Type Furnace; Heat-Treating Furnaces; Bench-Type and Floor-Mounted Furnace of the Hearth Type; Tool-Treating Furnaces; Tool Steel Tempering Furnaces; Furnaces for Annealing Castings; Continuous Hardening Electric Furnaces; Low Temperature Ovens; Furnaces for Baking Motor Armatures; Furnaces for Enameling; Electric Steam Boilers and Electric Sheet Mill Roll Heaters.

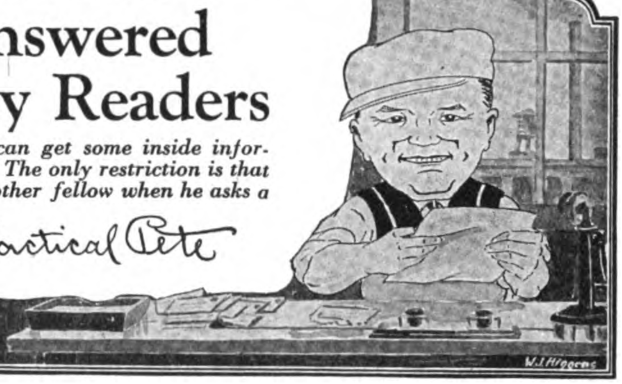
On Thursday there will be a general discussion on electrical repair shop practice. A general invitation has been extended to all steel mill operators who are responsible for plant maintenance to come prepared to take part in the discussion or bring up points for discussion on the convention floor concerning any phase of steel mill maintenance practice.

Arrangements have been made with several of the steel plants in the Pittsburgh district for inspection trips and the central stations in the district have also arranged to show convention members and guests the facilities for producing power that is used in the industrial sections of Pittsburgh. The inspection trips are in charge of James Farrington, Superintendent of the Electrical Department of the Wheeling Steel Corporation, Steubenville, Ohio, and particular details can be obtained by writing directly to him.

Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete



Who Can Answer These?

Method of Running Open Wiring in Mill-Type Buildings—I wish some of the readers of INDUSTRIAL ENGINEER would give me their opinion on the best way of running open wiring in buildings of mill-type construction. Assuming that No. 8 or larger conductors are used, should these be run on the roof trusses, on the ceiling beams or on the side walls? Should the conductors be supported by cleats or on knobs? What kind of cleats and knobs should be used? I should also like to know when and how strain insulators should and should not be used. Is there any preference as to the type of strain insulator? Any information you can give me will be much appreciated.
Worcester, Mass. R. S. T.

* * * *

Jackshaft Bearing of Mill-Type Motor Leaks Oil.—I am having trouble with oil leakage from the jackshaft bearings of mill-type motors. These bearings are large, running from 3½ to 7½ in. in diameter. They are split and held in brackets which are integral with the motor frame. Both ends of the babbitt bearing extend beyond the bearing housing. There is one oil ring in each bearing. The oil leaks out around the shaft at the ends of the bearings and then drips on the surrounding apparatus. At times the oil will be drawn out of the bearing to such an extent that the oil level will fall too low for the ring to dip in the oil.

I shall appreciate it if some of the readers of INDUSTRIAL ENGINEER will give me the remedies they have used to overcome this trouble.
South Chicago, Ill. O. C.

* * * *

Is it Good Practice to Weld the Bars in Squirrel-Cage Rotors?—We have a Westinghouse type CCL 2-hp., 1,200-r.p.m., 220-volt, three-phase motor, whose rotor bars were fastened to the end rings with one screw and soldered, and were insulated in the slots with fishpaper. This motor drives an air compressor and is controlled automatically. Recently it failed to start when the switch was closed and when it was discovered the winding was roasted, the solder had run out of the rotor and the slot insulation was destroyed.

The motor was rewound and the rotor welded. The bars were not insulated again. The screws holding the bars were left in and the spaces between the ends of the bars were filled clear up with Tobin bronze. Now the motor refuses to start the load, but carries it nicely after it is once started. The winding is the same as before and there are no hot spots in either stator or rotor. I took a light cut off the end rings, but this made the motor weaker.

I believe the rotor bars need slot insulation, but it will be a big job to cut off the weld and make new bars. Does welding these rotors usually cause this trouble? Previous to this I had always reinsulated and soldered the bars and had no trouble. If welding is good practice I want to do it, but if it is not I want to leave it alone. Any information you can give me will be much appreciated.

Also, can you tell me where I can get felt wicking, such as is used in the oil cups of small motors?
Regina, Sask., Can. G. D.

* * * *

Connecting Extension Bell to Telephone—I shall appreciate it very much if readers will give me some information on the following problem. In our engine room we have a telephone which operates from the city system, through our own switchboard. When the engines are running it is impossible to hear the bell ring unless some one is standing close by the telephone. I wish, therefore, to install a large alarm or extension bell. How should this be connected? What voltage is used to ring the telephone bell? What voltage and type of bell should I use? Is it necessary to use a relay for this bell; if so, what type is preferable? Please give me a wiring diagram showing how this bell should be connected.
Chicago, Ill. W. A. B.

* * * *

Use of Red Metallic on Repaired Armatures—After rewinding or repairing railway motor armatures a coating of Red Metallic and shellac is applied to certain parts—sometimes to the end of the commutator, or to the top of the bars where the leads are soldered on, to the projecting mica cone, and so on. Shellac mixed with it and applied seems to dry much quicker than straight shellac; also it makes a hard, permanent coating which has a certain cementing property, as when applied to the cone to prevent the fraying off of small mica pieces under operating conditions. However, Red Metallic is nothing but iron oxide, better known as iron rust, and is a good conductor of electricity. Therefore, I do not believe anyone, including myself, has any justification for using it, for it certainly is a conductor in the powdered state and probably is when mixed with shellac, although I have never had, or heard of, any trouble on account of its use. I use it as others do because the boss says to use it—and he does not seem to have any reason for so doing except that others before him have used it with no bad results.

Why could not the same quick-drying and cementing properties be obtained by mixing shellac with a non-conducting material such as plaster of paris or chalk? I should like to know what other readers think about the use of this systerious Red Metallic.
Oakland, Calif. S. H. S.

* * * *

Advantages of Star- and Delta-Connected Motor Windings—I wish someone would kindly give me some information on the following questions. Why are some three-phase motors star-connected, and some delta-connected? What are the advantages of a star-connected motor over one that is delta-connected? I shall appreciate it very much if someone will explain this to me.
Toledo, Ohio. F. H.

Answers Received To Questions Asked

Methods of Repairing Wooden Floors—We have found that the wooden floors in the trucking aisles and particularly at corners where trucks are turned, wear more rapidly than the remainder of the floor. I would like to know the experience of some of the other readers of INDUSTRIAL ENGINEER in making repairs for these sections of the floors. Also, we would like to know whether our readers favor flooring laid parallel to the line of trucking, crossways, or on a diagonal.
Monmouth, Ill. J. H.

In reply to J. H.'s question in the July issue, in a plant where I was employed a few years ago the trouble which he mentions was encountered, and was remedied by laying steel sheets over the surface of the floor. The thickness of the steel plates used was 3/16 in. and they were held in place by 1¼-in. wood screws, which were countersunk. The holes were drilled in the plates on 12-in. centers and the ends of the plates were butted to make a smooth running surface. This was found to be a desirable method for trucking aisles and although the screws would occasionally work loose, they were easily replaced. The surface of the plates being too smooth for trucks to have good traction the truckers would sprinkle the plates causing them to rust, thus giving the desired traction. This method of repairing floors so as to prevent undue wear on them has been proven to be very satisfactory and is used in quite a number of places having wood floors.

In regard to the way flooring should be laid, that is, parallel to the line of trucking, at right angles to it, or diagonally, I am in favor of laying it diagonally. When flooring is laid parallel to the line of trucking the wheels, as they come into contact with the ends of the boards, have a tendency to break them, if the boards are not all flush with each other. If they are laid at right angles the same results are obtained, but if laid diagonally this trouble is avoided all around. Maple used for flooring gives excellent results and 1¼-in. material is more durable than 13/16-in. The difference in cost should not be considered, as the additional strength and longer service which can be obtained from the heavier material will pay the difference.

I hope this will assist in solving J. H.'s flooring problem.

Quantico, Va. FRANCIS E. HARRIS.

* * * *

Locating Open Circuit in Running Winding of Fan Motors—(1) I have a Westinghouse 110-volt, a. c. fan stator which has an open in the running winding. The outgoing leads of this motor come out between the winding and the bottom of the slot, and the connections between the various pole groups are so covered with shellac that I cannot locate them. Will you please tell me the correct procedure for locating and repairing the open under these conditions, without destroying or damaging the present winding? (2) I wish to rewind a 220-volt, Robbins & Meyers fan motor for operation on 110 volts. This stator has twenty-four slots with a four-pole, three-phase winding which runs on a single-phase supply. I could reconnect the winding two-circuit or parallel but, as before, the three leads of the motor come out underneath the winding and I have not been able to trace the connections of the star nor of the different pole groups. How should this be done? (3) What is the proper procedure for removing the winding from an a. c. fan motor without spoiling it, as I wish to use it again? (4) When dismantling a motor on which the winding is impregnated with insulating compound, how can one tell whether the wire used is single or double-cotton covered or silk or cotton enameled? (5) I have two 220-volt d. c. motors, one series wound and the other shunt wound, which I would like to use as generators. What changes, if any, are necessary in order to use these motors as generators? Would they operate satisfactorily when driven by a Ford gasoline engine? (6) Not long ago I heard someone speak about winding a motor with two or three wires in hand when I mentioned a duplex winding. Does the term "duplex" refer to the number of wires in hand when winding?

Brooklyn, N. Y. I. T.

Taking I. T.'s questions in order: (1) On fan motors, the leads are brought out through the bottom of the slot, the connection being made on the opposite side to that on which the leads show up. The best way of locating the open is to warm up the stator by putting it in the oven and when hot, the leads can be raised and tested with the test lamp until the dead spot between groups or between lead and group is found. If heating alone does not loosen the windings, if the wire is silk- or cotton-covered, soak the winding with alcohol and then bake at a low temperature, say 150 to 200 deg. F.

(2) The above also applies to the Robbins & Meyers fan stator; this is a straight three-phase grouping with one phase of higher resistance and a phase splitter in the fan base. It is impossible to lay down any set procedure to cover these two cases, as a great deal depends upon the individual's experience, common sense and ability to reason things out.

(3) The only method that I know of is to soak the whole stator in gasoline or alcohol until all varnish is soft; then strip the stator. However, as soon as the gasoline evaporates, the insulation on the wire will become brittle. I think that trying to save the old wire for use again is a penny-wise-and-pound-foolish procedure.

(4) To determine whether a wire has a single or a double layer of insulation, warm up a small piece of wire; then the covering can be unwound. If a single covering is used bare wire will show; if it is double covered, the top layer will unwind in the opposite direction to the bottom layer; that is, it is impossible to unwind both coverings at the same time. To determine if the wire has an enamel covering, warm the wire sample and unwind all of the cotton or silk covering and wipe with a rag wet with gasoline. If the copper shows with very little rubbing, there is no enamel present. Bending the wire sharply in a gas flame will cause enamel to crack off and give out sparks. Varnish will burn, but enamel on a wire will glow and crack. To tell whether the covering is silk or cotton, soak in gasoline until all of the varnish is removed and then tell by the feel of the insulation.

(5) In order to operate a series motor as a generator, the speed should be increased about 10 per cent; this also applies to a shunt motor. If the gasoline engine drives the motors at the proper speed, that is, 10 per cent above the nameplate rating, and at constant speed, they will operate satisfactorily as generators.

(6) The term "duplex" does not refer to the number of wires in hand per coil, but to the type of winding. In single lap windings, the number of paths is equal to the number of poles, but if the winding is a duplex lap winding, it will have twice as many paths as poles. With single wave windings there are but two paths or circuits regardless of the number of poles. When a duplex wave winding is spoken of, it means that the winding has four paths.

Detroit, Mich. A. C. ROE.

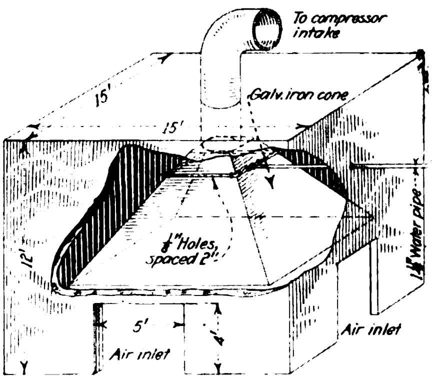
* * * *

Air Filter for Intake of Air Compressor—I should like to get a little information from someone who may be inclined to lend a helping hand. The plant where I am employed has installed two feather-valve air compressors. These compressors are subjected to coal dust, coal smoke and sand and we are having trouble with the valves. After cleaning them they operate satisfactorily for about 24 hours, and then begin to hang and stick.

Will someone please give me complete details of a suitable screen or air filter that I could make and use on the intake of these compressors?

Norfolk, Va. W. B. E.

In answer to the question asked by W. B. E. in a recent issue of INDUSTRIAL ENGINEER, I would suggest that he build the type of air filter shown in the illustration. As will be seen, this consists of a wooden or concrete vault, 15 ft. square by 12 ft. high with 4-ft. by 5-ft. openings on all four sides. On



The air for the compressor is passed through a spray of water to remove most of the dust and impurities.

the inside is mounted a cone-shaped compartment, the top 1 ft. from the ceiling of the vault and the bottom reaching to the level of the top of the openings. This cone should be made from galvanized sheet iron and may be either round or square as desired, although the square form gives the better results and is easier to make. The air outlet from the filter may be a pipe made of No. 12 gage galvanized iron and leading from the top of the cone. This outlet pipe should be 2 in. larger than the inlet to the air compressor. A clearance of 2 ft. should be allowed between the cone and the wall.

A 1¼-in. water pipe containing ⅛-in. holes spaced 2 in. apart should be led all around the cone, about half-way up. If the pressure of the water is not enough to give a good spray over the edges of the cone, larger holes should be used in the pipe.

It will be seen that all of the air entering the openings in the vault will have to pass through the water spray before it goes up the cone and into the compressor and most of the impurities will be removed. This device gave excellent results on a 5,000-cu. ft. installation and I believe it would solve W. B. E.'s problem.

Chief Electrician, EARLE N. DILLARD.
Booth-Kelly Company,
Springfield, Oregon.

* * * *

Selection and Application of Carbon Brushes—Can any of the readers of INDUSTRIAL ENGINEER give me any information on how to choose and properly apply the various grades of carbon brushes? I should like to know how a practical man can by inspection and simple tests choose a suitable brush for a job or determine what application a certain brush is most suitable for. I have seen references to the electrolytic action between brass collector rings and carbon brushes and should like to know the cause of this action and if there are any means of overcoming it.

W. A. P.

Smooth Rock Falls, Ont., Can.

Replying to W. A. P. in the June issue, he should, first, consider the carrying capacity of the brush and the peripheral speed of the commutator. In any case the brush must be capable of carrying the maximum current to be transmitted.

Second, the characteristics of the machine in question must be taken into consideration. In the case of non-interpole machines, or those having severe commutating characteristics, the grade of brush used should have a fairly high contact drop, in order to suppress the reactance voltage. If the commutating characteristics are not so severe a grade of brush with lower contact drop should be used to reduce voltage loss.

Third, the abrasiveness of the brush will depend on the condition of the commutator. If the mica is undercut little or no abrasiveness is required, just enough to keep the commutator clean. For a machine on which the mica is not undercut the brush should be abrasive enough to keep the mica cut flush with the copper. The degree of abrasiveness required will depend on the ratio of copper to mica and whether the mica is sheet mica or built up of flakes; the latter material is softer and requires a less abrasive brush than sheet mica insulation.

Newport, Ky. C. D. DISPENNETTE.

Trouble with Single-Phase Induction Motor—Can some of the readers of INDUSTRIAL ENGINEER tell me what is the matter with a small, single-phase induction motor which fails to start when the switch is closed? Both the main and starting windings and the centrifugal switch have been tested and seem to be all right. After closing the line switch and giving the rotor a quick start by means of a string, the rotor will sometimes quickly come to a stop, or apparently lock. Then, possibly the next time the switch is closed the motor will start from rest and run normally. This is a standard make of four-pole, 60-cycle, 110-volt motor. I shall certainly appreciate any suggestions you can give me as to what is the trouble and how it can be remedied.
Uhrichsville, Ohio. R. F. P.

In reply to the question asked by R. F. P. in a recent issue of INDUSTRIAL ENGINEER, I would suggest that he check the clearance between rotor and stator. If this is found to be satisfactory, the centrifugal switch should be examined to see if it is possible that sometimes it may not make good contact. Also, it sometimes happens that one of the windings (usually the starting winding) has an open circuit, that will open and close due to vibration. If the ends of such a broken wire make contact the motor will start and run normally, but if the ends of the wire become separated the motor will not start.
Muncie, Ind. GEORGE CROPPER.

* * * *

Does Voltage Above Normal Affect Power Bill?—We buy power from a local power company at a line voltage of 13,000 volts. The voltage in the plant is supposed to be 550, but we have an average voltage of 640 to 700. Our motors are of the induction type, ranging from 1/10 to 50 hp. Will there be any loss of power with the voltage higher than normal? If so, what will it amount to? When the voltage jumps from 620 to 700 our indicating wattmeter will rise around 200 watts. Will this increase the reading of our kw.-hr. meter in proportion, or what per cent will it be? I have been checking very closely the power consumed and find that when we have high voltage the power runs higher also. I shall be very grateful for any information you can give me.
Rock Hill, S. C. L. W. M.

Answering L. W. M. in a late issue, if the voltage in the plant is supposed to be 550, it should not exceed 600 volts for good results. Induction motors will operate satisfactorily when the voltage is 10 per cent above or below normal, but this range should not be exceeded.

A change in voltage causes a change in current; then for under-voltage the current will be increased which will cause an increase in the copper loss. To compensate for this increased copper loss at reduced voltage the iron losses will be reduced. If the voltage is increased above rated voltage the current will be reduced and the copper losses reduced, but the iron losses will be increased.

In other words, with an increase in voltage there will be a certain amount of energy saved in the copper losses while at the same time there will be an increase of energy wasted in the iron losses. The result is that the increased iron losses will be greater than the decrease in the copper loss. Consequently with an increase in voltage there will be also an increase in the amount of power consumed. The per cent increase of power consumed may be more in proportion than the ratios of the squares of the impressed voltage. It will also depend upon the per cent of full load the motors are pulling. If the motors were highly loaded with the voltage as high as 700 they would surely run hot and would be very likely to become hot enough to burn out, this heating being caused by the increase in the iron losses. Another item to check up on with such a large increase in voltage above normal is the power factor. With an increase in voltage above normal the power factor will probably be reduced. For motors rated at 550 volts, 700 volts make for poor economy and should not be used.
Muncie, Ind. GEORGE CROPPER.

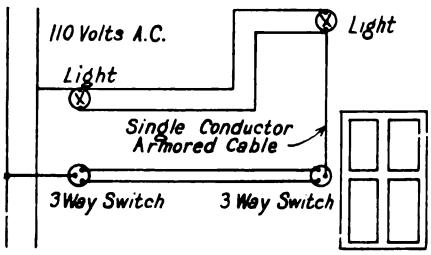
* * * *

Answering the inquiry by L. W. M. in a late issue, an example will probably give him food for thought on his problem. Assume that he has a load of 100 amp. at 640 volts, which will give 110.7 kva. or 88.57 kw. at 80 per cent power factor on a three-phase system, which I presume he has. The same current load of 100 amp. at the voltage he should receive, 550 volts, will amount to 95.1 kva. or 76.1 kw. at 80 per cent power factor. This would mean a saving of 12 kw., which in thirty days will make a decided difference in the power bill. Also the motors will run cooler at their rated voltage.

It is an excellent plan to have the voltage slightly above rating in order to compensate for line drop in the feeders, but ninety volts is more than is necessary on a 550-volt system of small size.
Donnacona, Que., Can. LEE F. DAN.

* * * *

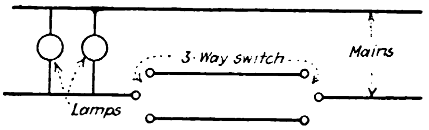
Protecting Wires from Mechanical Injury—How should the 5-ft. stretch of wire from floor to switch, shown in the accompany diagram, be run for proper protection from mechanical injury? Knob and tube work is used throughout on this job, and the wire in question is to be installed in an unfinished stairway



leading to a cellar. There is no partition through which to fish the wire. Further, when the wall of the stairway is finished it is to be back-plastered; so there will be no partition even then. I shall appreciate it if some reader can tell me the best way to meet the above conditions.
Concord, Mass. D. F.

In answer to D. F.'s question in a recent issue of INDUSTRIAL ENGINEER, I wish to call attention to the fact that according to your drawing, you have used the old "hot-wire shunt system," which is now obsolete. This method of wiring is not in accordance with the regulations of the National Board of Fire Underwriters, and thus is not considered good practice. This point is explained in Article 12, Paragraph a, Section 1204 of the 1923 edition of the National Electrical Code. The illustration shows the proper method of connecting three-way switches.

In regard to protecting wires which are run as shown in your sketch, I would suggest that you consult Article 6, Section 611, Paragraph m of the 1923 Code. As I interpret it, this tells you to reinforce each wire with flexible tubing and pull both lines in a ¾-in. pipe which is securely fastened in position.
Philadelphia, Pa. EDWIN H. LAMBERT.



Proper method of connecting two three-way switches.

* * * *

In answer to D. F.'s question in a late issue, I would suggest that on account of the stairway being back-plastered, he use a short run of metal conduit or wooden moulding for protection.

While looking over his sketch I notice that he has both sides of his line running through the switch-box. I would not advocate this method of wiring for three-way switches as Code rules require that only one pole of the circuit be carried to such switches.
Nashville, Tenn. C. B. FRANKLIN.

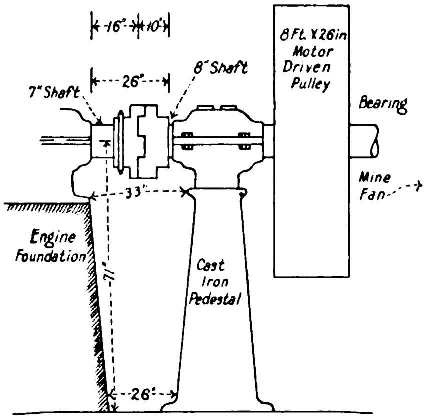
* * * *

From the question asked by D. F. in a recent issue, I take it that the installation must come up to National Electrical Code rules. Therefore, according to Section 1204a of the 1923 edition, the three-point switches must be connected by two neutrals as only one pole of the circuit is allowed at each switch. In the stairway a line of ½-in. conduit may be run from the attic or second-story floor to the basement, a G condulet fitting being inserted at the proper place for the switch, if this is of the snap, surface type. In this case the ends of the conduit must be equipped with approved fittings having separately bushed holes, such as A or B condulets. The wire must pass from the conduit to open work without joint, splice or tap and the fittings may be enclosed, if installed in this manner.

If a snap switch is used and greater protection against mechanical injury is desired than is provided by the above arrangement, I have had the following approved by a member of the State Inspection Bureau on jobs where a certificate of title had to be presented upon completion of the job:

In place of the G condulet, a 4-in. outlet box may be inserted in the usual way and an open base snap switch fastened in it. As a cover, use a 4-in. sign receptacle ring with the concave side turned outward. This ring will just rest on the metal switch cover and the switch button will project slightly beyond the surface of the cover. If it is more convenient to carry the circuit wires to the basement through another partition, then all that would be necessary is a short piece of conduit terminating at the box or condulet. If preferable, a No. 170 Union switch box and flush switch may be used.
Auburn Junction, Ind. W. C. GRUBB.

What Kind of Clutch Should Be Used Here?—I should like to get your opinion on a clutch to be used for driving a mine fan. The sketch shows what we have at present, but it is not very satisfactory, due to the flywheel effect of fan and pulley, which causes excessive wear on the square-jaw clutch and results in back-lash at every stroke of the engine.

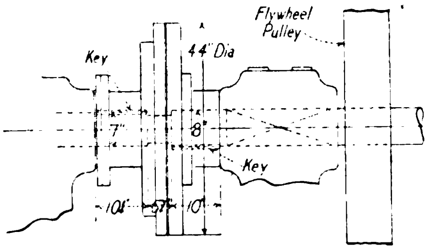


The engine is rated at 250 hp. at 175 r.p.m. and operates at full capacity, in one direction only. The clutch is used so that the engine may be thrown out part of the time and the fan driven by a 250-hp. motor belted to the pulley.

What type of clutch could I get that would fit into these dimensions and be able to carry the load?
Bicknell, Ind. H. S. B.

With reference to H. S. B.'s question in a late issue of INDUSTRIAL ENGINEER, the accompanying sketch shows an electro-magnetic clutch in place of the mechanical, manually operated jaw clutch. Jaw clutches have not proven satisfactory when operated direct connected with steam engines, due to the pulsating effect. A magnetic clutch can be used to fit into the dimensions shown. A clutch of this type permits a certain amount of variation in angular velocity which is taken up on the brake lining. The clutch can be operated, or engaged, when connected to the steam engine and disengaged when the fan is belt-connected to the motor, on 115 or 230 volts direct current by means of a push button, to give remote control. This is a decided advantage over any form of mechanical type of clutch as it eliminates the manual operation of engaging, which usually requires barring the flywheel to get the jaws in position.

The sketch shows a 44-in. diameter magnetic clutch the use of which is based on condition that the clutch be engaged before the engine is put in operation, and depends on the characteristics of the fan and the WR^2 value of the flywheel pulley. If it is desired to engage the clutch after the engine is in motion, a larger clutch will be required and the size will depend on the load to be accelerated.



Installation of 44-in. Cutler-Hammer magnetic clutch, rated 250 hp., at 175 r.p.m.

Further information can be obtained by writing to the Cutler-Hammer Mfg. Company, Milwaukee, Wis.

E. H. LAABS.
Engineer, Printing Equipment Dept.,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

* * * *

Will This New Winding Be Satisfactory?—I have a 2,200-volt, three-phase, 60-cycle, 20-hp. motor that I want to rewind for 220 volts, three-phase, 60 cycles. This is a squirrel-cage motor, having seventy-two slots. The original winding was seventy-two coils wound with twenty-six turns of No. 19 wire, two-parallel, connected series star, the coils laid in slots 1 and 10. Would a winding consisting of thirty-six coils of sixteen turns of No. 14 wire, three-parallel, coil span 1-and-16, be satisfactory? How should this winding be connected? I shall appreciate it very much if someone will help me out on this.
Albany, Ga. B. B.

With reference to the questions asked by B. B. in the June issue, the number of poles is not given, but I judge that this is a six-pole motor from the coil pitch used. If so, it can be reconnected for 220 volts by using a six-parallel delta connection. This works out as follows: The volts per phase with a line voltage of 2,200 and a series-star connection is (2,200 ÷ 1.73) = 1,270 volts approximately, which is also the line voltage for a series-delta connection. Then if a six-parallel delta connection is used, the line voltage would have to be (1,270 ÷ 6) = 211.6 or 8.4 volts under 220 volts, which is less than 10 per cent variation and is satisfactory. The winding suggested, that is, thirty-six coils of sixteen turns of three No. 14 wires in parallel would give 390 volts per phase for a series-delta connection. For a series-star connection, the line voltage would have to be (390 × 1.73) = 674.7 volts and a three-parallel star connection would require a line voltage of (674.7 ÷ 3) equals 224.7 volts, which is satisfactory, and three No. 14 wires would have ample cross section. However, the pitch of 1-and-16 is too long a throw if the motor has six poles; then the 1-and-10 pitch is practically 80 per cent pitch and for six poles, seventy-two slots, the 1-and-16 coil pitch is over-pitch 25 per cent, which will give a slightly lower value for the chord factor than the 1-and-10 pitch, but the coils will be hard to wind and will require a greater weight of copper and more end room than the seventy-two coil winding. I suggest, therefore, that he use a basket winding of thirty-six coils of sixteen turns of three No. 14 d. c. c. wire, pitch 1-and-10 and connect the coils three-parallel star for 220 volts.
Detroit, Mich. A. C. ROE.

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In answer to the question asked by B. B. in the June issue of INDUSTRIAL ENGINEER, he does not state the speed of the motor nor the number of poles. However, if the motor has seventy-two slots and seventy-two coils with a coil pitch of 1-and-10, it is evidently a six-pole motor, which would give a coil pitch of 75 per cent of full pitch.

This motor is already wound for 2,200 volts and connected series-star. As a series-delta winding will stand 57.73 per cent of the voltage that a star winding will, if we reconnect this motor series-delta it will then be suitable for (2,200 × 57.73) = 1,270 volts. Now, as the motor has six poles, we could also connect it six-parallel delta, as the series-delta connection will generate 1,270 volts. Then if we connect it six-parallel delta we will obtain (1,270 ÷ 6) = 211.6 volts which is 8.4 volts less than required; or (8.4 ÷ 220) = 3.8 per cent under-voltage, which will be close enough under ordinary operating conditions and thus avoid necessity of rewinding the motor.

But if the motor is to be rewound, I would use seventy-two coils and if there were sufficient end room to permit, I would make the coil pitch 1-and-11 and use thirteen turns of No. 13 d. c. c. wire per coil, connecting three-parallel delta, which will give 220.7 volts. However, if the end room is not sufficient for the 1-and-11 pitch, then use the 1-and-10 coil pitch as in the original winding, using thirteen turns of No. 13 d. c. c. wire per coil and connect three-parallel delta which will give a winding for 211.6 volts. This will be close enough for ordinary use.
Muncie, Ind. GEORGE CROPPER.

* * * *

In answer to B. B.'s question in the June issue of INDUSTRIAL ENGINEER, if the stator of this motor has not been stripped of its windings and they are in good condition, they may be reconnected six-circuit delta and operated on a 220-volt circuit satisfactorily. A series-delta connection is good for 58 per cent of 2,200, or 1,276 volts. Then for six-circuit delta, (1,276 ÷ 6) = 212.66 volts which is within 3½ per cent, approximately, of the desired voltage and is satisfactory.

If, however, the present winding is in bad condition, he may use the winding he mentioned. However, this calls for a basket winding and it would be better to use a winding consisting of seventy-two coils of three No. 14 wires, using eight turns per coil with a pitch of 1-and-10 as before and connect the winding three-circuit star.

If there is not enough end room for the No. 14 wires in the slots when properly insulated, three No. 15 wires will give as good a winding as the original one. I trust this will give B. B. the desired information.
San Anglo, Tex. CURTIS EBNER.

* * * *

Replying to B. B. in the June issue, it is possible to rewind this motor for 220-volt operation, assuming that the speed is to be the same for both voltages. Winding this motor for 220 volts, there will be seventy-two coils of eight turns per coil of No. 14 d. c. c. wire, coils to be connected six-parallel star with a coil pitch of 1-and-10. The slot insulation will be one thickness of fish-paper and one thickness of varnished cambric each 0.010 inch thick. Varnished cambric should also be used between phases.

These coils will go in easily because the insulation for 2,200 volts would be considerably more than for 220 volts. If this motor is connected for six poles, as I assume, there will be eighteen groups of four coils per group connected in series. JAMES R. MCCORMICK, JR.
Putnam, Conn.

Trouble with Single-Phase Motor—I have a ⅓-hp., 110-volt, 60-cycle, single-phase induction motor of the split-phase starting type, having its windings on the rotor and the squirrel cage on the stator. This motor recently showed evidence of heating when running on light load and finally refused to start, even without load. On testing the windings, they were found to be free from opens, shorts and grounds. The centrifugal switch functions all right but shows burning at the contact points. The bearings were renewed and the contact points cleaned, after which the motor started on no-load when first reassembled, but after that it again refused to run. The rotor was free in the bearings and did not rub on the stator, also the brushes were operating all right. Will someone suggest what may be the cause of the trouble?
Newark, N. J. H. M.

With reference to H. M.'s question in a late issue of INDUSTRIAL ENGINEER, the symptoms he describes are those ordinarily produced by loose rotor bars and the simplest remedy is to have the ends of the bars welded or brazed or, as a last resort, resoldered to the end rings. Loose bars increase the resistance of the secondary and lower in proportion the pulling power of the motor. The fact that he is able to get the motor to start sometimes, and not at others, is probably because some of the bars are still making contact.
Seattle, Wash. W. MONTELIUS PRICE.

* * * *

Rewinding 6-Volt Motor for 110 Volts—I have a Gray & Davis 6-volt d.c. motor which I would like to convert into an electric drill to operate on a single-phase, 110-volt, 60-cycle circuit. Is it possible to rewind this motor? It is equipped with a brush rocker and brush spacing device.
Logansport, Ind. L. E. G.

L. E. G. asks, in a recent issue, about rewinding a Gray and Davis 6-volt motor for operation on 110 volts alternating current. If this motor has a cast frame, which it probably has, the change which he proposes is not practicable, owing to the heating which would be caused by eddy currents. It is to avoid this heating that all alternating-current apparatus is built with laminated iron cores. Further, I doubt if there are the proper number of slots and bars in the armature for operation on alternating current.
Seattle, Wash. W. MONTELIUS PRICE.

* * * *

Meaning of Motor Nameplate Data—Can some reader tell me what "Open Hp. 10, Amps. 75.—Closed Hp. 5½, Amps. 43," means in the case of a General Electric, d. c., compound-wound motor which has the following nameplate data: No. 95790, Form B, Speed 650, Volts 115, Open Hp. 10, Amps. 75—Closed Hp. 5½, Amps. 43. Pat'd Feb. 14-88 up to Jan. 31-99.
Mazatlan, Sinaloa, Mex. J. C. L.

In answer to J. C. L., in a late issue, "open" and "closed" horsepower refers to whether the frame is open or closed, so that it does or does not allow good ventilation.

Some frames are closed absolutely tight to keep out water or dust, and this arrangement, by not providing any ventilation, does not permit the heat created in the winding to pass away. As the limit of any power agent is reached at a certain degree of heat, lack of ventilation materially decreases its allowable load or horsepower.

Confined heat will also lower the limit of a generator or transformer to such a serious degree that any attempt to carry its rated load in amperes or kilowatts would very likely cause a burn-out. Thus, an over-heated generator, motor or transformer is not always overloaded; it may simply be lacking in ventilation. In other words, if these could be kept cool by some very ingenious scheme the loads they could carry would be almost unlimited. So, as heat is the limiting factor, the rating of an entirely inclosed motor is about one-half that of the open type. A motor properly located will carry its full load, as shown in the nameplate, with a temperature rise of not over 40 deg. C., or 75 deg. F. above the surrounding air. It may then feel hot to the hand, but it is safe. If the back of the hand cannot be held against the motor for more than a few seconds it is then hot enough to be tested with a thermometer, which has its bulb surrounded by cotton or waste. If the motor is too hot, reduce the load.
New Britain, Conn. H. S. RICH.

* * * *

In reply to J. C. L.'s question in a late issue, "closed" means that the motor is enclosed so as to practically prevent the circulation of air through the interior. "Open" means that there is no obstruction to ventilation other than that imposed by good mechanical construction. When the motor in question is "open" it will develop 10 hp. without overheating, and when "closed" it will develop only 5½ hp. without overheating.
Fort Worden, Wash. E. I. PEASE.

* * * *

In answer to J. C. L.'s inquiry in a recent issue, motors are classified according to the degree of enclosure provided in their frame construction as, (1) the open type; (2) partially closed; (3) totally enclosed.

The temperature rise governs the load that a motor will operate under successfully. For instance, the motor in question may be operated open (windings exposed to the surrounding air) and have a rating of 10 hp. and 75 amp.; or it may be used with the end frames closed (no ventilation) with a rating of 5½ hp. and 43 amp. Enclosed motors are generally used in dusty, gaseous or wet places or where they are exposed to the weather.
WILLIAM J. MILDON.
Supt. of Power and Equipment,
Madeira-Hill Coal Mining Co.,
Philipsburg, Penna.

* * * *

In reply to J. C. L.'s inquiry in a recent issue, he has in his possession a motor designed to operate either open or as an enclosed motor. When operating as an open motor, it would develop 10 hp. at a full-load current of 75 amp. and will not exceed the given temperature rise of the motor, but when operating as an enclosed motor, it will only develop 5½ hp. at a full-load current of 43 amp., without overheating, which may cause serious damage to the motor and might cause the solder to be thrown from the armature leads where they are connected to the commutator. Care should be taken to see that this motor is not loaded more than 5½ hp. when operating enclosed.
Sales Department,
Diehl Manufacturing Co.,
Elizabeth, N. J. F. P. LANING.

Why Does This Watt-Hour Meter Run Backwards?—I have a 150-kw. motor-generator set driven by a synchronous motor which is operated from a 2,200-volt line. When the set is started why does the watt-hour meter run backwards? The fact that it does run backwards surely does not mean that no power is used in starting. (2) When this machine is running at no-load should the ammeter on the exciter be adjusted so that the watt-hour meter runs very slowly, or so that it stands still? (3) When the watt-hour meter runs backwards, as mentioned, what is the cause of the trouble and what will be the effect. Will it harm the machine in any way? I shall appreciate any information which your readers can give me on these points.
Beaverdale, Pa. M. A. L.

Referring to the question asked by M. A. L. in the May issue of INDUSTRIAL ENGINEER, (1) when starting a synchronous motor, the field current is lagging, and a lagging current tends to pull down the voltage of the circuit; hence it tends to lower the applied voltage and also lower the power factor.

I would suggest that M. A. L. have the meter tested by a competent meter man, instructing him to give careful attention to the lag adjustment of the meter, for a small per cent error in adjustment at unity power factor will increase considerably at low power factor. It is, however, characteristic of the induction watt-hour meter to run backwards at a power factor of less than 50 per cent on one leg of a polyphase circuit.

(2) This will depend to some extent on the condition of the lagging of the meter, but over-exciting of the motor should produce a leading current causing the meter to run in its proper direction.

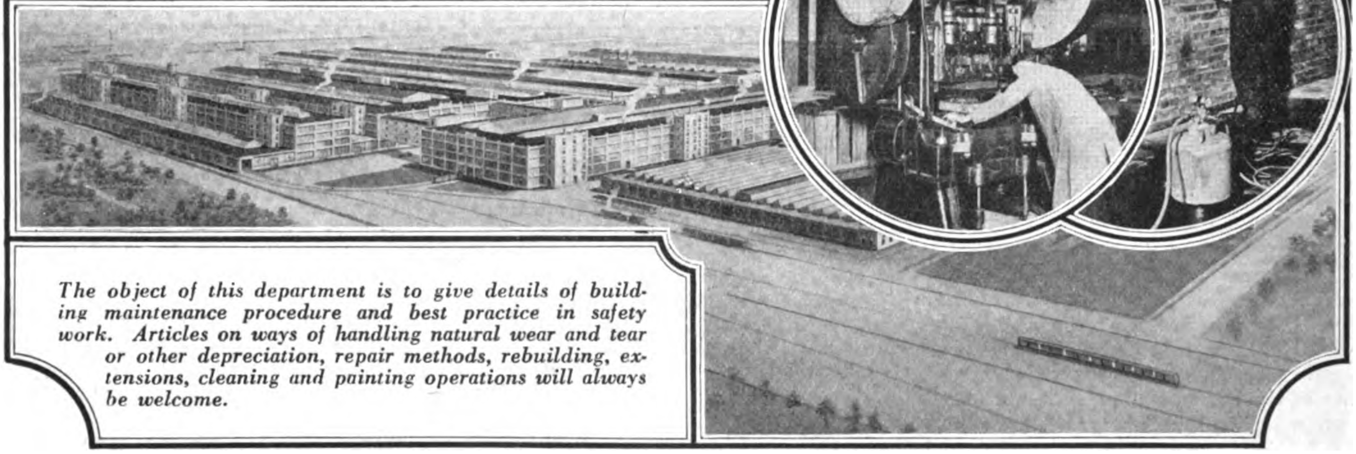
(3) If the machine has been running to the present time, I can not see where the reversal of rotation of the meter would affect the motor in any way.
Goldfield, Nevada. PHIL D. COMER.

* * * *

In reply to the questions asked by M. A. L. in the May issue, I would say that his trouble with the watt-hour meter is undoubtedly caused by wrong connections. It is a well-known fact that one of the elements in any three-phase watt-hour meter tends to run backwards at power factors under 0.50. The starting current of a synchronous motor will have a power factor under 0.50; therefore, an open circuit in one of the coils of the fast element of the meter would cause it to perform in this manner. A blown potential fuse could also give the same results. An error in phasing out the secondaries of the instrument transformers might also cause a meter to run backwards under conditions of low power factor. If the trouble is caused by an open circuit it can easily be located by opening each potential circuit successively and noting if the meter stops with either element cut out. If not, the connections should be checked and special attention given to the polarity marks and the proper phasing.

In answer to the second question, the field current of a synchronous motor should be adjusted until the line current is at a minimum at normal load. No attention should be given to the watt-hour meter for this adjustment.
Hibbing, Minn. LYLE HENDRICKS.

Building Maintenance and Plant Safety



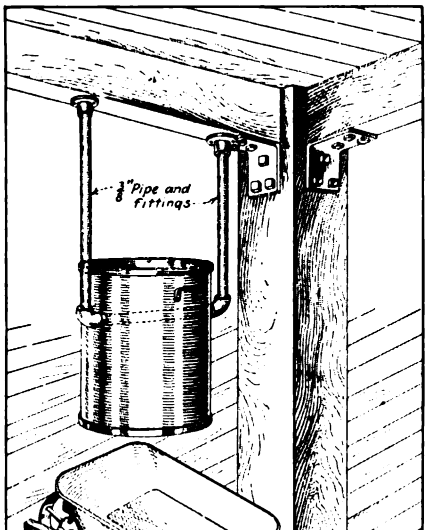
The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Hanging Up the Shop Waste Cans for Convenience

WASTE CANS, particularly those in which the floor sweepings, containing turnings, grit and other heavy shop trash are placed, are so heavy that the lift from the floor for the purpose of dumping into wheelbarrows usually requires the services of two men. To avoid this extra work, a number of installations of suspended cans were made in one shop. These outfits were similar to the one shown in the illustration and consisted of vertical supports from the beam overhead with a cross bar supporting the waste cans slightly above the center.

The cans stand clear of the floor and are dumped by simply pushing the wheelbarrow up to the can. One man can readily tilt it and dump the contents into the barrow. An additional feature is that the usual collection of dirt under or around the can is avoided.

Washington, D. C. G. A. LUERS.



It would require two men to pick this can up and dump it. When suspended, however, one man can easily dump it into a wheelbarrow.

Using Motor Truck in Place of Power Hoist

AN INSTANCE where a little ingenuity saved considerable money occurred when we were erecting a new building at the plant, the first we had that was built of steel. It was three stories high and stood apart from the rest of the factory buildings. The elevator was to be installed as soon as the steel work was up so that it could be used to hoist the various other building materials for the sides and walls.

We were doing the work with our shop operating force, as business was slow enough so that we could take the men from the shop and put them on the building. The steel was purchased fully fabricated, and laid down on our grounds. The crew that did our shop repairs, installation and general maintenance were fully capable of becoming foremen for the gang from the shop and directing the construction of the new building.

One thing we lacked was equipment for hoisting the steel columns and beams. We had sheave wheels and steel cable but no kind of hoist—and we didn't want to buy such equipment if it could be avoided. With what we had, and our motor truck, we got along without buying.

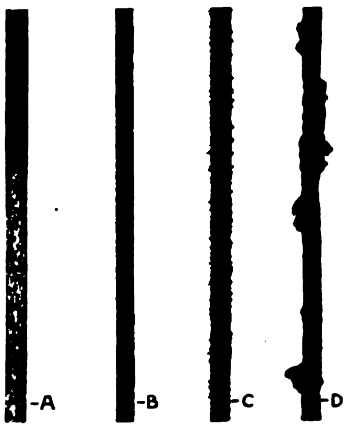
We arranged an 8-ft. piece of steel beam with a sheave wheel on top and angles at the bottom for bolting on at any of the regular connections. This became a temporary gin pole, easily portable and all that was then needed was several other wheels set at the proper places to guide the cable, which finally emerged horizontally from the new building and was carried to one of the towing hooks at the back of the truck.

We used the truck as a power hoist. On low gear, it has a speed of 3 miles an hour, which is a slow walk, and which can be further reduced by clutch slipping. With a careful driver it was thus possible to hoist the beams and to hold them suspended while the steel worker put in the temporary bolts.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.
Middletown, N. Y.

Tests Prove That The Strength of Rope Cannot Be Judged by Appearance

SAFE CONDITIONS demand that ropes such as are used over pulleys or to suspend tools with a counterweight, should not be used after they become unsafe. The problem is, however, to know when a rope has worn



To all appearances these four ropes are of the same quality and would be graded according to strength in the order shown here.

Tests showed, however, that the second rope from the left *B* is almost as weak as the rope *D* at the right. These ropes were used to suspend air or electric drills directly over the workman's head by means of a pulley and counterweight. The tests proved so conclusively that rope could not be judged by its appearance, that twisted wire rope is now used for this work.

enough to make it unsafe. The Safety Committee of the Auto Body Company of Lansing, Mich., recently made some strength tests of new and used rope to see how nearly the strength could be judged from its appearances. These ropes were used to hold electric or air drills which in the body plant are counterweighted and suspended directly over the workmen for their convenience. The rope is similar to the heavy braided rope used on counterweights for windows. A new rope, as at (A), in the test stood up under a pull of 565 lb. The rope, shown at (B), which is of the same quality, had been in actual service before the test was made and to all appearances was in good condition. However, it registered only 243 lb. in the test. The rope at (C) had shown considerable wear and appeared to be in dangerous condition, but it withstood a pull of 315 lb. The rope at (D) was only able to withstand a pull of 210 lb. before breaking, or a little less than the better appearing rope at (B).

These tests demonstrated the difficulty of estimating the strength of any rope simply from its appearance, and emphasize the fact that the strength of a rope lies in its core and not in the outside. The rope at (B) may have been wet, pinched or suffered some other accident or deterioration which was not obvious to the user.

As a result of these tests, twisted wire rope is now used to suspend drills and other tools on counterweights which are often hung directly over the workman, within his reach at any time. As this rope is twisted, not braided, when a strand breaks it is impossible to use the rope any longer as the broken strand uncoils from the body of the rope and it will not pass through the pulley. T. MURDOCK.

Michigan Mutual Liability Co.,
Detroit, Michigan.

How Coal Conveyor Reduces Cost of Yard Storage

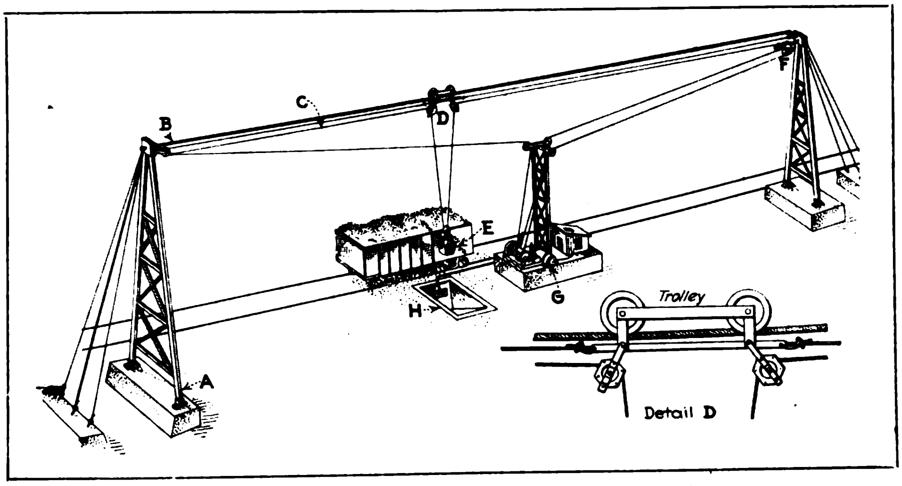
UNLOADING COAL offers one of the best and most common examples of what material-handling equipment can do. How this has worked out in one instance is shown by the savings made by the coal conveyor installed in the yard of a large foundry, as shown in the accompanying illustration. This has not only saved time but has enabled the plant to cover a larger area and at much less expense for unloading and storing. Sometimes, as many as twenty or more cars are waiting to be unloaded and the conveyor is busy 24 hr. a day.

The loaded bucket makes a trip from the pit at the car, to either end of the yard and returns in 5 min. It can deliver about 120 tons every 10 hr. Formerly, a 40-ton carload of coal required eight men, 3½ hr. to shovel the coal over the side of the car and then 5 hr. more to move it farther back to storage. With this electrically driven conveyor, only two men are at the car, one man operates the windlass, and another trips the bucket to unload and convey to any distant point along the cable-way a 40-ton carload every 3 hr.

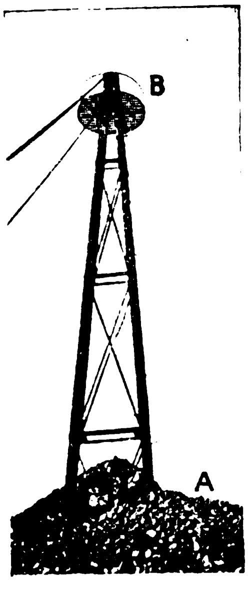
The main features of this coal-handling equipment which is a Model C hoist, made by the Godfrey Conveyor Co., Elkhart, Ind., are shown by the halftone illustration. Two steel masts, (A) each 50 ft. high, are erected 400 ft. apart, with a crow's nest at the top for convenience in making repairs to the trolley and sheaves. A main supporting cable of 1¼ in. diameter is carried over each of the masts and anchored to concrete bases 10 ft. long, 3½ ft. wide, and 10 ft. deep. The ½-in. hoisting cable extends from the bucket over the trolley sheaves to the mast at each end, then down the center mast and around the windlass, as shown. This cable has been renewed only once in three years. The operator at the windlass can readily locate the position of the bucket and trolley at the various coal piles by painting white marks a few inches long on the cable. The trolley truck is of forged steel, with bronze bushed wheels. It is kept well painted all the time. The bucket is of electrically welded steel and its movements up, down, forward and reverse are controlled by levers at the windlass. It opens at the bottom by releasing a spring trip, or it will trip itself, by letting it drop suddenly on a coal pile. The sheaves for the hoisting rope are of steel, about 12 in. in diameter and are fitted with Hyatt roller bearings. The windlass (G) is driven by a 7½-hp., 440-volt, three-phase, semi-inclosed, squirrel-cage-type motor, inclosed in a waterproof box. The starter is close by in a covered cabinet.

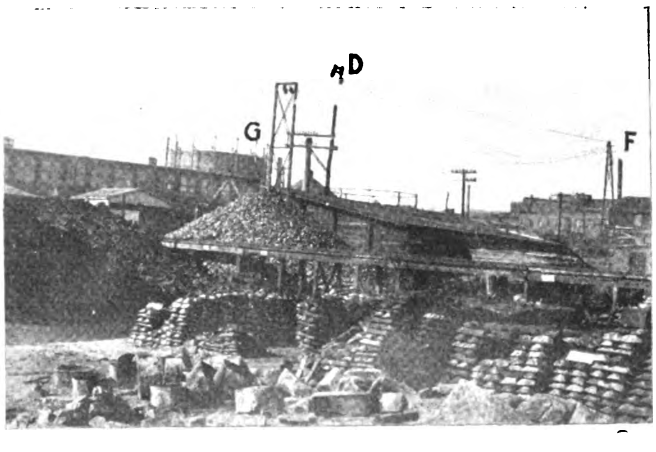
In unloading, the car of coal is placed over a chute or pit and dumped. The operator lowers the bucket into a loading pit (H) alongside the track. This pit is about 20 ft. long, 4½ ft. wide, 9½ ft. deep at the lower end and 3 ft. deep at the upper end. This gives the bottom of the pit an incline and the bucket slides down this incline on a long track rail to the lower level where it rests while being filled through a chute from the car on the track above. In winter this loading pit is entirely boarded over when not in use, and at other times a compressed air siphon pump keeps out any rain water. A sliding gate controls the discharge of coal into the bucket. When filled the operator hoists the bucket, moves the trolley to the part of the yard where the coal is to be dumped, trips the bucket and returns it to the pit to be filled. For night work, two 100-watt lamps are used, one at the pit and the other higher up to enable the operator to guide the trolley and bucket over the pit.

New Britain, Conn. H. S. RICH.



This sketch gives in detail the construction and operation of the coal conveying system, described in the accompanying item. The two masts are located 400 ft. apart.





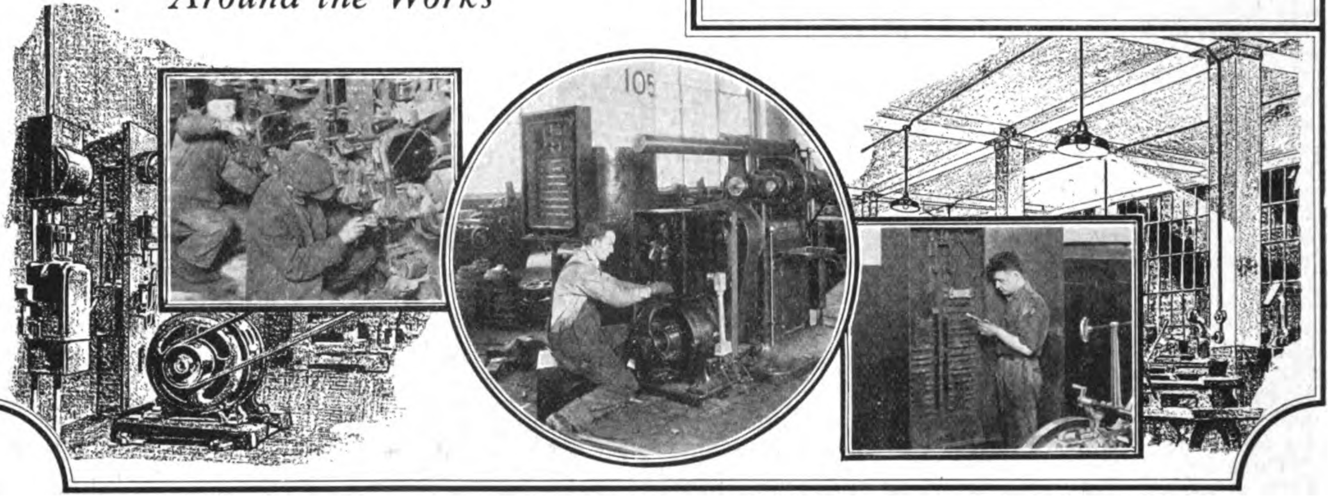
These show a general view of the storage yard and one of the masts with its crow's nest.

With this coal carrier, a 40-ton carload of coal can be unloaded in 3 hr. and place at any position in this storage space. It formerly required eight men, 3½ hr. to unload the car and 5 hr. more to move it into storage.

Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



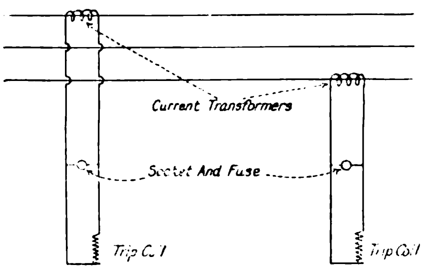
Eliminating Trouble Caused by Line Surges Due to Lightning

RECENTLY a large mining company was troubled, during electrical storms, by interruption of service due to the oil switch on the primary side of the line opening without apparent cause.

After a careful check had been made to make sure that there was no overload or line surge caused by the operating conditions, it was decided that lightning was causing the trouble.

As the overload trip coils were set as high as they could be without endangering the connected apparatus, it was found necessary to insert some kind of a lag or choke in the circuit. The connections were not changed to the trip coils, but an ordinary porcelain lamp socket was cut in parallel across each circuit from the current transformers to the trip coils as shown in the illustration. In this socket was screwed a fuse plug with a rating not greater than the setting of the trip coils.

This scheme has been tried out for several months during the most severe storms and no trouble was experienced with the switch opening under lightning surge, although the fuse would blow, allowing the coils to operate on overloads other than those caused by the lightning.



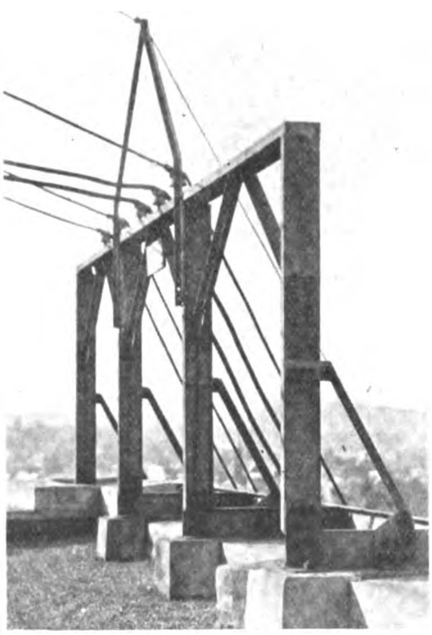
A fuse, in a porcelain socket, was cut in across the leads from the current transformers to the trip coils of the oil switch.

This little kink may help someone solve a similar problem in some other desert country.

Goldfield, Nev. PHIL D. COMER.

Strong and Simple Supports for Conductors on Roof of Plant Building

WHEN aerial conductors are used between the power house or substation and the various departments of an industrial plant, the question of providing proper supports for the conductors deserves special attention. The illustration shows a strong and simple corner roof structure which was erected for carrying cables over the top of a New England factory to a lower building in the same plant. This support was built of structural steel bars and channels anchored into concrete bases and strongly braced. As will be seen a V-shaped piece, extending above the top of the support, carries an overhead ground wire. This rack or support will easily accommodate nine cables of 500,000 to 1,000,000 circ. mil section.



The support is made of structural steel bars and channels anchored to a concrete base and strongly braced.

Boston, Mass. H. S. KNOWLTON.

Cause of Trouble in Compensator Traced to Lost Screws

WE HAD a metal planer that was driven by a 20-hp. General Electric motor with Type NR compensator. After the outfit had run about a year and a half, the starting lever developed the fault of dropping out of its running position. The electricians, of course, sought the trouble in the no-voltage release and adjusted the rods. There was some improvement but the trouble occurred repeatedly until finally the planer man got in the habit of keeping a stick handy to prop the lever over.

In one of these sessions, several contact shoes were renewed, after they were discovered with burned faces. Again an improvement for a time. Later, a more careful electrician in working on the relay panel came to the conclusion that one of the dashpot pistons fitted too tightly in the cylinder and he eased off the surface after working hours. But the next day the planer operator was using his stick again.

During a lull in planer work, the department foreman told the planer operator to take off the oil pan on the base of the compensator so that we could see if any of the contacts were in need of renewal. The contacts seemed to be all right.

On his own hook, the machinist ran his hand through the pan of oil before putting it back again and fished out five screws of various sizes. Three of them proved to belong in various places in the compensator framework. These

were put in place and so doing visibly drew the frame into line. Following this simple repair, there has been no further trouble with the "no-voltage release."

On jobs which are giving trouble continuously, it practically always pays to investigate everything which may even remotely be the cause. Also, when trouble "seems" to come from a supposed cause, which cannot be located, time will be saved by looking for a new cause. DONALD A. HAMPSON.

Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.

Construction of Switchboard and Framework for Supporting Conductors

RECENTLY I had occasion to install a switchboard in the engine room of a rolling mill and was instructed to make the whole job, including the method of running the conductors, "neat and simple." As this was something new to me, I enlisted the aid of the mill electrician and the results of our combined efforts are shown in the drawing, which gives the details of the construction of the switchboard and the framework for supporting the conductors leading from the board.

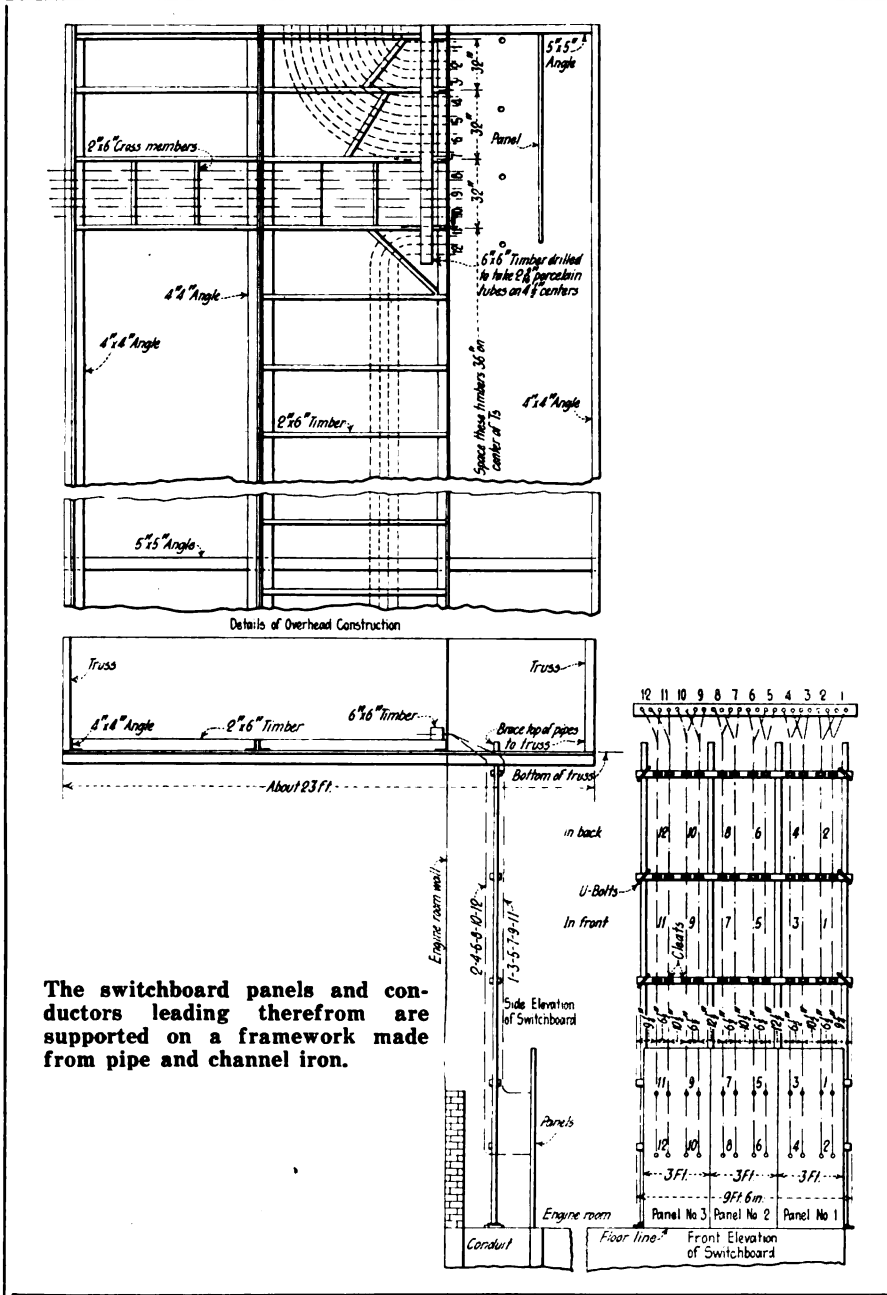
As will be seen we supported overhead on the roof trusses just outside the engine room a 6-in. x 6-in. timber about 10 ft. long, through which twenty-four holes were drilled. These holes were spaced on 4½-in. centers and were of the proper size to take the porcelain tubes used. Twelve d.c. circuits were led to the various buildings about the mill. They were numbered from 1 to 12 and the conductors passed through the holes in the beam in numerical order, starting at one end as shown.

The framework on which the conductors are supported back of the switchboard consists of 2-in. pipes for the uprights with floor plates at each end. The horizontals, placed about 4 ft. 6 in. apart are 8-in. channel iron in pairs, one in front of and one behind the uprights. They are held in position by means of ⅝-in. U-bolts. The conductors are fastened to these channels by means of suitable porcelain cleats and 5/16-in. bolts. The odd-numbered circuits are led down on the front channels (toward the switchboard panels) and are connected to the upper row of terminals on the three panels. The even-numbered circuits are led down on the rear channels (away from the panels) and are connected to the lower row of terminals on the three panels.

We followed out instructions to make the wiring "neat and simple" so well that connecting up the switchboard and various circuits presented no difficulties whatever. The method described here for running the conductors of a d.c. system having two wires to each circuit can be readily adapted to a three-wire system.

In the event that anyone wishes to install a similar switchboard and supporting framework, I would suggest that the framework be placed about 18 in. behind the switchboard and that about a 2-ft. clearance be allowed between the framework and the rear wall. This will give ample room for wiring and inspection, and the like. There should also be a fair-sized passageway on each end of the switchboard for Safety First.

Bridgeport, Conn. D. FLIEGELMAN.



The switchboard panels and conductors leading therefrom are supported on a framework made from pipe and channel iron.

Tracing Trouble With Automatic Motor Starter to Vibration

THE FACT that many difficulties are caused outside of the equipment itself, which shows the result of the trouble, was vividly impressed on me by my experience with an automatic motor starter controlling a 7½-hp. motor. This was connected to a flight conveyor of a coal-handling system and caused much trouble by the continual burning and blistering of the copper contacts of the first contactor.

Naturally, the first step taken was to check the panel wiring against the print. This was found correct. Next the contact pressure was satisfactory, the voltage was normal and the amperage load never ran as high as the rating of either the motor or the starter. Finally, another panel of the same size and rating was substituted, but with the same results. These simple tests indicated that the trouble lay outside the starter.

After studying the installation, it was thought that the trouble might be due to vibration caused by the flight conveyor jarring the contacts enough to cause them to arc and blister. The panel was moved and securely bolted to a building column which was almost free from vibration. This evidently had been the cause, as after the panel was put in the new location the trouble was entirely eliminated.

H. E. REINGOLD.

New Philadelphia, Ohio.

Some Suggestions For Taking Care of Induction Motor Slip Rings

SLIP RING gear of an induction motor with a wound rotor is the part most likely to give trouble and calls for proper attention if reliability in operation is to be secured. The deterioration of insulation resistance between the rings is a fruitful source of breakdowns. When current is switched on to a stator while the rotor is stationary and on open circuit, the voltage between the slip rings is comparatively high. This is due to the fact that the stator develops a rotating field which revolves at a constant speed regardless of the rotor speed. Thus with the rotor stationary the voltage induced is a maximum because the relative movement between the rotor conductors and stator field is also a maximum. This relative movement becomes less, and likewise the voltage induced, as the rotor gains speed. The opportunity for leakage or possible breakdown is thus greater during the initial starting period. To keep the slip-ring voltage down at starting, motor starters and controllers should always be so designed that the rotor circuit is never interrupted. Although this reduces the voltage across the slip rings at starting, the voltage usually is sufficient to cause trouble if the insulation is defective.

The effective resistance of insulation to leakage may be greatly reduced by accumulations of conducting material on the surfaces connecting live portions of apparatus. In the case of slip rings, these accumulations consist chiefly of carbon dust, where carbon brushes are employed, and brass dust resulting from abrasion of the rings by hard brushes. The only method of treatment under such circumstances is to clean frequently all insulation surfaces between the slip rings with compressed air and brush with a soft brush, which should be small enough to reach and loosen dust in parts difficult of access.

Probably nothing increases the possibilities of insulation breakdowns on slip rings so much as accumulations of oil and grease, which attract dust and impair the surface resistance of all insulation. This trouble is always most effectively remedied by attacking it at its source and making slip-ring bearings leak proof. The alternative is frequent cleaning and the application of oil-proof varnish at frequent intervals. The necessity of thoroughly cleaning the parts before applying the varnish cannot be over-emphasized. It is a good plan to wash the parts clean with benzol, or a similar solvent, before applying the varnish.

Slip rings of machines that operate intermittently and are situated in damp places require regular attention to prevent deterioration of the insulation. An occasional coat of shellac or varnish is usually sufficient to maintain the insulation in good condition. In all such situations fibre insulation should be avoided as it readily absorbs moisture and may cause breakdown. Under normal conditions of operation, the heat developed by the brushes and slip rings usually suffices to keep the insulation from getting damp.

Slip rings that are totally enclosed are of necessity mounted on the end of the motor shaft. This means that the rotor slip-ring connection must be run through the shaft in order to pass the bearing and reach the rings. It is necessary to prevent accumulations of dirt and oil in the openings where these connections enter and leave the motor shaft.

Frequent applications of varnish at such points are a good safeguard against the development of insulation troubles. To prevent abrasion of the conductors, small pieces of presspahn (the trade name on the Continent for fullerboard or pressboard) should be placed between the conductors and the shaft at the points where these enter and leave the shaft.

Unfortunately, and without any apparent reason, slip-ring motors are usually fitted with carbon brushes. Their use with direct-current machines can be easily understood, as the question of commutation is a deciding factor in selecting brushes. However, in the case of slip rings, where it is simply a question of collecting current, the higher the conductivity of the contact between brush and ring the better. In the writer's experience, no type of brush is better suited to the purpose than one formed of a mixture of copper and graphite, similar to a well-known grade of Morganite brushes. An outstanding instance of the improvement effected by making a change from carbon brushes to this type of brush occurred with a 200-hp. motor with totally-enclosed slip rings for use underground in a mine. Under normal conditions and with the carbon brushes supplied with the machine, the abrasive action of the brushes caused endless trouble due to accumulations of carbon and metallic dust between the slip-rings. Moreover, the slip-ring gear reached a dangerous temperature soon after starting up. This was due to the high resistance contact between the brushes, and rings and to the heavy rotor current which had to be carried. The temperature often was sufficient to melt out the solder from the brush connections, setting up arcing and causing frequent stoppages. The difficulty was overcome by replacing the carbon brushes with a set of Morganite copper-graphite brushes. These brought the working temperature down to an almost imperceptible increase above that of the surrounding atmosphere. In addition, the rings soon developed an exceedingly smooth surface and after two years neither the brushes nor rings showed appreciable signs of wear. Moreover, trouble from carbon and metallic dust entirely disappeared.

Walton-on-Thames, Surrey, England. L. FOKES.

Switchboard Control for Emergency Lighting Service for Industrial Works

IN A large iron works where the total load was until recently carried on three 13,000-440-volt, 150-kw. transformers, with the lighting service again stepped down to 110 volts, many shutdowns were experienced because storms damaged or put the long cross-country lines from the power company's station entirely out of commission. As a result, the plant was often left with no power or light for an hour or more.

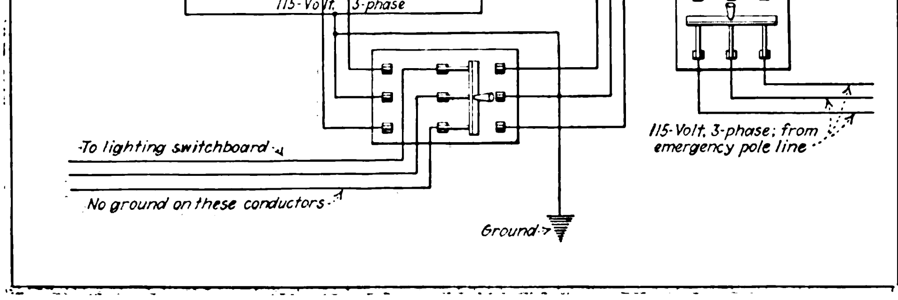
By using the plant's steam boilers and turbines on the air blowers, many a heat of iron was saved but with no lighting, production was seriously delayed.

The local power company has recently supplied this plant with 110-volt alternating current for emergency lighting by means of a special feeder from their generating station. This helps to keep the plant going when the power is off the high-tension feeders.

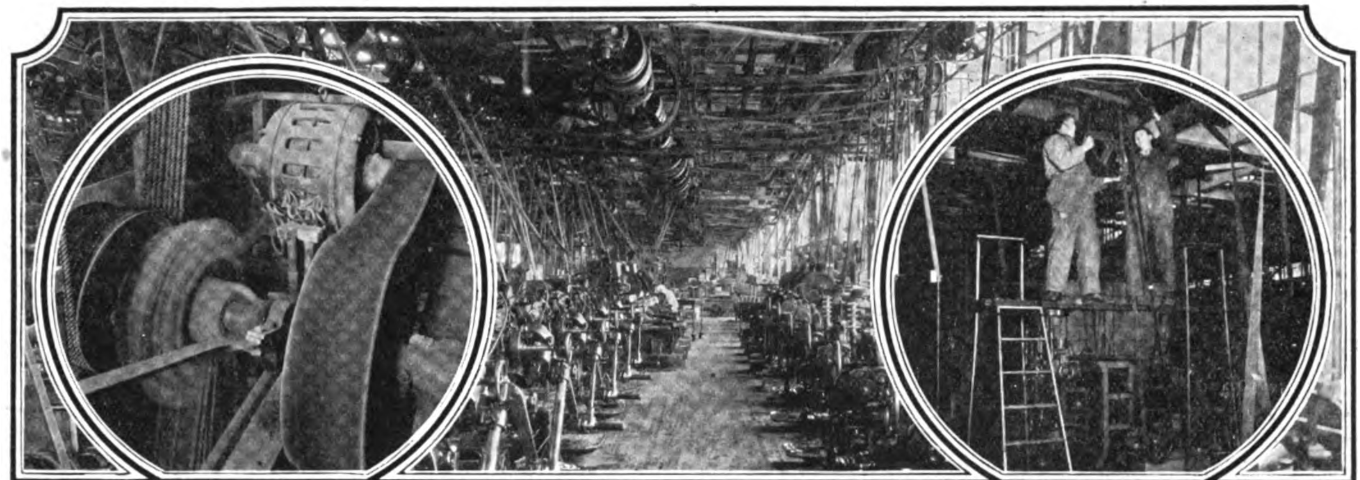
As will be seen from the illustration, the emergency lighting feeder can, in emergency, be connected directly to the main lighting switchboard. When the emergency is passed, the lighting service can quickly be thrown back onto the main 440-110-volt transformers.

Both the regular and the emergency supply systems are separately grounded, fused and metered, but they cannot be thrown in parallel as the service to the lighting switchboard is controlled by a double-throw switch.

New Britain, Conn. H. S. RICH.



The lighting switchboard is controlled through a double-throw switch which allows lighting service to be supplied either through the main transformers or from a 110-volt emergency line from the local central station.



Mechanical Maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

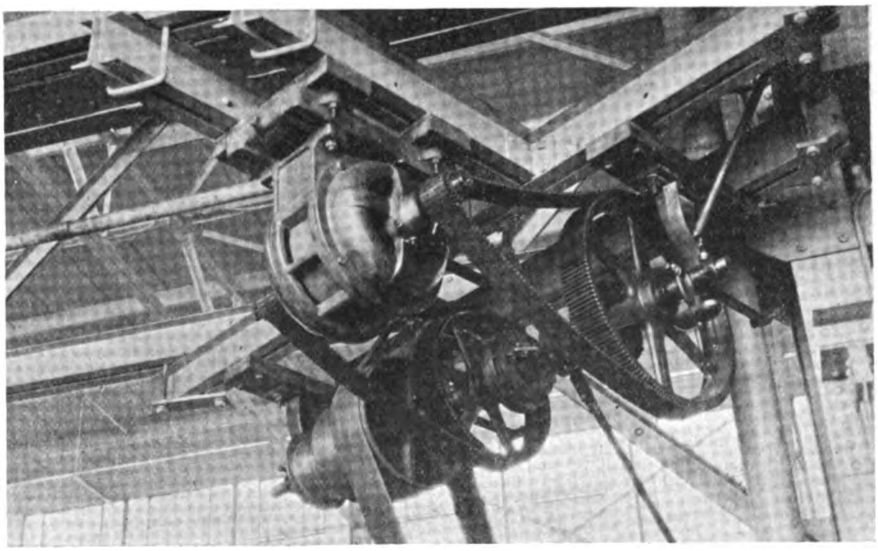
Revamping Countershaft Drive to Get Double Capacity

A CHANGE in design of a high-pressure, carbon-dioxide compressor cylinder for a refrigerating system, which the Brunswick-Kroeschell Co., Chicago, Ill., are manufacturing, requires that it be bored out of a solid casting instead of a cored casting. Economical machining requires that much heavier cuts be taken than formerly. The belt, however, would not pull the heavy load. The six-step cone pulley on the countershaft and lathe head was changed to a three-step pulley so that a 6-in. belt could be used instead of a 3-in. belt. This, however, made possible only three changes of speed, without back gears, instead of six as formerly. By the use of a double-headed motor and chain sprocket of two different diameters on the countershaft, it was possible to get the full six-speed changes desired. With this arrangement, the lathe could not be driven in reverse but as it was to be used for boring and turning only on this job, the reverse drive for threading was not necessary.

Link-Belt silent chain drive was used on this countershaft because it permitted the large reduction of the small motor sprocket without an extra jackshaft that would probably be necessary otherwise. This mounting is compact and fits in with the shop plan as practically all the machines in this plant are driven by individual motors. Also, the individual drive unit permits placing the lathe at an angle with the other equipment in the shop and also independent of any other machinery, which would not be possible in a group drive. The motor is controlled by a start-and-stop push button conveniently mounted on the lathe head. The safety switch and starter are mounted on the nearest building column.

A change in manufacturing methods required that more power be delivered to the lathe.

The six-step cone pulleys were changed to three-step pulleys so that 6-in. belt could be used instead of a 3-in. belt A double-headed motor and two sizes of sprockets with Link-Belt silent chain gave the six speeds desired. A reverse drive could not be obtained as the chain belt cannot be crossed, but this was not necessary as the lathe was not to be used for threading.



Crane Bearing Trouble Reduced by Pressure Lubrication

DUE to vibration a great deal of trouble was experienced from losing the large, brass grease cups lubricating the bearings of one of the cranes under my care. The caps for the grease cups were lost repeatedly and could not be recovered, as they dropped in the ashes and cinders beneath the crane. This not only meant the expense of replacement, but the crane suffered from lack of lubrication while the caps were gone. Also dirt which entered was detrimental to the bearings, causing unduly rapid wear.

It was decided to replace all of the cups with Alemite fittings such as are used on automobiles. With these fittings there is nothing to come loose and hence there was no further trouble or expense occasioned by the loss of grease cups.

After using the new system for a short time, several advantages that outweighed the original cause of the change, were noticed. A considerable saving in time was experienced by lubricating this crane with the high-pressure system. This was important, inasmuch as the crane operator is kept very busy with the crane operation and has little time to spare. I found that he could lubricate all of the bearings in 15 min. with the grease gun, whereas fully 30 min., and possibly more when he had to refill the grease cups, were required by the old method. Often when screwing down the grease cups, the oiler would find one cup was empty and would not refill it until several others needed refilling. Consequently this bearing would have to run without lubrication until some

other cups needed refilling. With high-pressure lubrication each grease nipple receives its regular amount of grease at every greasing period. With the old method an open can of grease was carried up on the crane to fill the grease cups. The crane is in a very dirty location and in consequence, dirt got into the grease can and also into the grease cups during the refilling process.

When empty the grease gun is filled with clean grease from a closed container in the shop or in the oiler's shanty. Due to the nature of the hose connection of the grease gun and the special fittings there is no chance of dirt getting into the bearings when forcing in grease. The high-pressure gun functions best with better grades of greases. A good grade of grease will not clog or harden in the fittings, whereas a poor grade will. Hence a better grade of grease was used and this in turn resulted in better service from the bearings than would have been obtained from the cheaper grease.

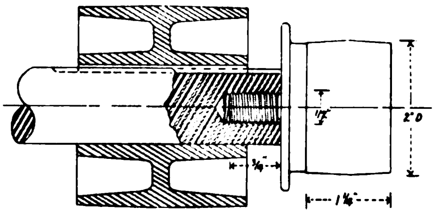
O. C. CALLOW.
Chief Electrician,
Trumbull Cliffs Furnace Company,
Warren, Ohio.

Adding Pulley Makes Motor Do Two Jobs

WHEN an oil filter was added in one plant it was found that with an extension pulley on the shaft of a motor connected to an air compressor it would not be necessary to install a separate motor. The method of attaching this pulley extension to the motor shaft is shown in the accompanying sketch and photograph. When it is not necessary to operate the air compressor the tension of the drive belt is released by raising the idler with a lever. The slack belt is then rested on the motor bearing so that it will not rub on the pulley. This idler, which is behind the pulley in the photograph, provides the necessary tension on the air compressor belt and increases the arc of contact on the small pulley. A loose pulley could hardly be used here.

The photograph shows a Richardson-Phenix Type SS oil filter (A) with a capacity of 4 to 8 gal. per hr., connected to a Goulds rotary oil pump (B), which has a by-pass or unloader valve of somewhat greater capacity than the filter. These are piped to a two-compartment sump tank (C) of the turbine-gate operating and governor system of a hydro-electric plant. The piping passes behind the sump tank and is connected beneath the floor. The pump is driven by a pulley extension on the end of the motor-shaft as already explained.

By adjusting a three-way stop cock (D) oil is pumped from the farther end of the sump tank into the filter through the spout (E). The oil flows by gravity through the filter and back to the sump tank through the three-way stop cock (F) which is adjusted to pass it but



The drawing shows how the extra pulley was added to this motor shaft.

shut off the pump suction. By readjusting the three-way stop cocks (D) and (F) the oil may be pumped out of this end of the sump and flow by gravity into the other end.

Also, by readjusting the two three-way stop cocks (D and F) one eighth of a turn, both suction pipes may be shut off. A barrel of dirty oil is placed near the pump, a temporary suction put into it and connected to the bottom of the four-way fitting (G) and the oil is pumped from the barrel to half fill the filter. The temporary suction is shut off, stop cock (D) readjusted and the oil circulated through the filter until clean. Then a three-way stop cock (H) is turned shutting off the spout (E) and opening a spout (I) to discharge into a clean barrel until the filter is empty. This equipment is filtering the sump tank contents continually and may be used for treating other collected oil as described.

W. A. PLANT.
Smooth Rock Falls, Ontario, Can.

How Careless Assembly Caused Trouble with Chain Drive

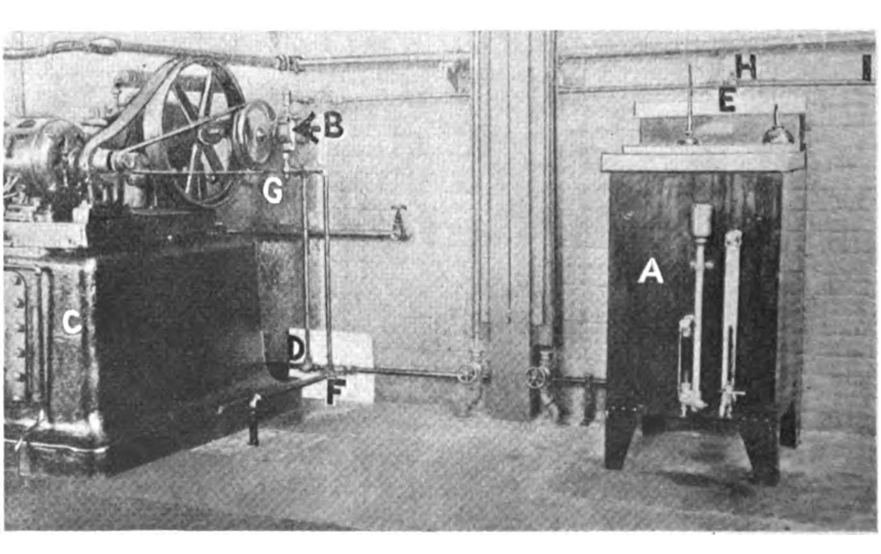
THAT the real cause of an operating trouble does not always lie where it appears to be is well shown by the following experience with a chain drive. A 7½-hp. motor drove a mixing machine through a Morse chain 3 in. wide with about 3 ft. centers. This drive superseded a belt and was very satisfactory. An engineer, in going over plant details, noticed what appeared to be a click or jump to the chain at the small sprocket on the motor on about every tenth revolution of the motor. In moving the chain over the sprockets by hand this was not noticeable but when the motor was operating at 1,120 r.p.m. it constituted what a particular man would call a defective installation, but one which would easily pass in everyday operation.

The engineer suspected that the click was at the joint where the chain ends had been joined, but a close examination did not reveal any joint that could be picked out as the shop-made one. However, the man who had put on the chain quickly picked out the joint by some scratches that he had made. Questioned, he remembered distinctly, he said, putting in both of the pins that form the rocker connection and the neatness of his finished work made it seem that he must be right.

An examination of the working side of the teeth did not show anything; so the engineer passed on, but he felt certain that there must be something wrong inside those links. Later in the day, in going by the spot and seeing the machine idle, he took the opportunity afforded by the afternoon sunlight thrown on the chain to again examine the inside. He was rewarded by finding a brightened spot on the back of one chain tooth at the joint on the side of the tooth which did not carry the drive!

When the joint was unriveted it was found that only half of the split pin had been put in. Evidently, in assembling the chain the machinist had put in the stationary part first and had pushed it out unnoticed when he shoved in the rocker member. The space thus left had permitted the link ends a slight amount of slack and the back side had rubbed on the sprocket teeth each time it came around, causing the jump and clicking sound. With both halves of the pin in position, the chain ran quietly.

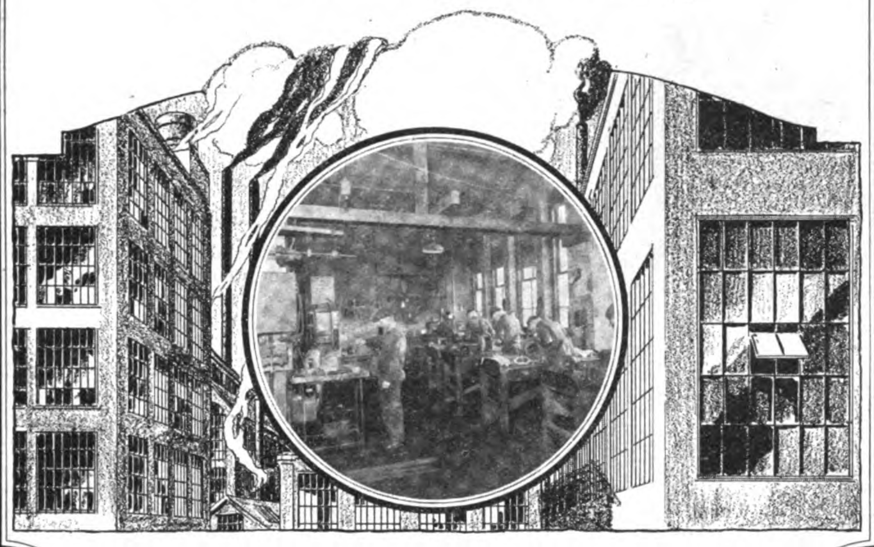
DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.



A small pulley at the end of the shaft was added so as to drive the oil filter with the same motor used on an air compressor.

This 2-hp., three-phase, 60-cycle, 550-volt, 1,750-r.p.m., Robbins and Meyers motor is connected up with an idler to drive an air compressor. This small pulley was added to the end of the shaft so that it could be used to drive the filter. While used on the filter the idler is loosened and the belt of the air compressor is thrown up over the bearing so that it does not rub on the pulley. The operation of the pulley and filter is explained in the accompanying item.

In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Wrench for Gripping Round-End Stud Pins

WHEN putting in round-end stud pins or screwed dowels the usual practice is to leave an extension on these pins for turning them with a pipe wrench, or flat sides if other wrenches are used. After the pins have been inserted the projecting portion is sawed or broken off, a tool score being made at the place where it is to be cut.

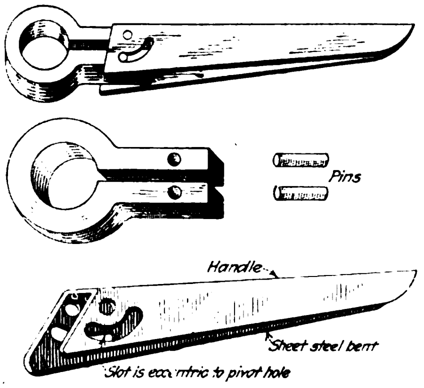
The wrench shown in the accompanying illustration was devised to overcome the need for the extra length and also as a means of removal, as is frequently necessary, without destroying the usefulness of the pin.

The tool is easily made up, is convenient to use, and because of the shape, can be used on the ratchet wrench principle. The gripping jaw of the tool is made of forged steel. A hole is drilled for the stud pin and the piece is split and drilled for the two drive-fit handle pins.

The handle is made from steel plate bent to form a convenient grip, drilled for the pivot pin and slotted with an eccentric slot for the clamping pin.

As will be obvious from the sketch, the wrench pressure is obtained by a direct pull on the handle; increasing the pull increases the grip. The smooth gripping jaws, while capable of a heavy grip due to the pin position and the eccentric slot, will not mar the smooth surface of the pin.

Washington, D. C. G. A. LUERS.



The round end of the wrench is slipped over the stud which is to be removed. A clockwise pull on the handle will tighten the jaws around the stud, to turn it.

Easy Method of Removing Sleeve Bearings From Motors

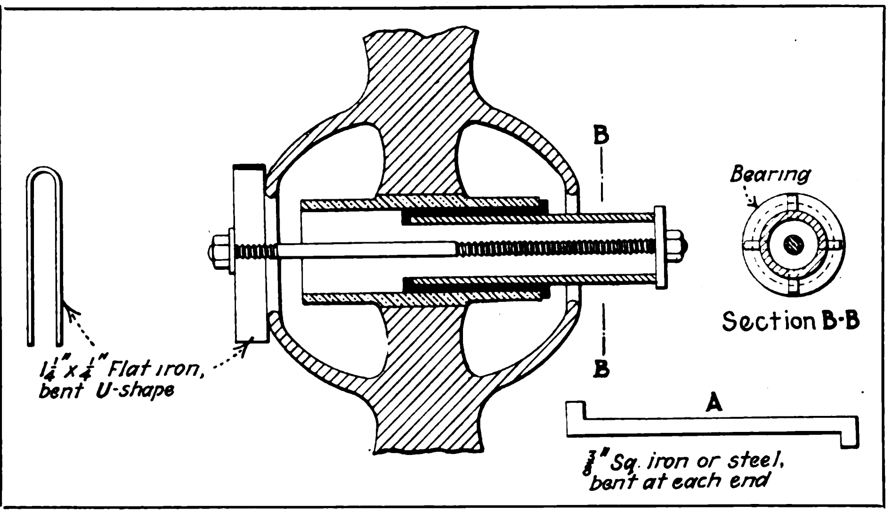
THE accompanying diagram explains an easy and efficient method of removing bearing sleeves from motor housings, especially on motors where the outer end of the housing is just large enough for the shaft. These bearings are almost the same size as the sleeve, which does not permit using a hammer to drive the sleeve out.

The device shown consists of three or four hooks made of square iron or steel bent at both ends, as shown in (A) of the illustration. These are slipped into the sleeve after the shaft is removed and are held against the inside of the sleeve by a piece of pipe, as shown. A bolt with a long thread is then passed through the sleeve and a washer put against the end of the pipe. The other end of the bolt passes through a piece of flat iron which is bent in a U-shape and rests against the inner end of the housing. A nut is screwed onto the bolt and when the nut is tightened the sleeve is forced out.

This device may be used for any diameter of sleeve bearings by employing different sizes of pipe and washers.

Temiskaming, Que., Can. J. H. SAUVE.

The bearing sleeve is pressed out of the housing by means of four square iron strips which are bent at each end and forced against the sleeve by tightening the nut on the long bolt.



Method of Applying Varnish to Laminations

IN THE construction of armature cores and other electrical apparatus with a laminated metallic structure which is subjected to repeated reversals of magnetic flux, it is necessary to insulate the laminations from each other. If the laminations are not so separated by insulation, the eddy current power loss is practically as large as in a solid iron body.

The most effective and simplest way of insulating the discs from each other is to coat each with a thin film of varnish. This film is about 0.002 in. or 0.003 in. thick and the varnish used is known as core-plate varnish. There are several varieties of this varnish on the market, each with qualities which suit it for particular uses. For motor armatures, the qualities to be desired are high heat endurance without oozing or flaking, and ease of application at the proper body to give the correct film thickness. The varnish must thin easily so that the shop will have no difficulty in getting it to the right consistency for use in the machine. And when at that consistency the varnish must be evenly applied so that the film will be uniform in thickness.

Some core-plate varnishes contain an insulating pigment, and some do not. This matter is, however, of secondary importance, as the potentials to be insulated are of a very low order.

Varnish is best applied to the discs by a machine built for the purpose and consisting of a pair of printers' rolls. Application with a brush or spray is tedious, and dipping is unsatisfactory because too much varnish is applied and it is too heavy at the edges.

It is occasionally necessary or desirable to insulate laminations in the repair shop and for such work a machine which uses metal rolls and was made in an Eastern plant could be used to advantage.

This machine was made from an old tinners' roll, consisting of two steel rollers 3½ in. in diameter and 18 in. wide, with adjustable spring tension on the upper roll. A slot ⅝ in. wide and 1 in. deep was cut near each end of each roller to keep the varnish from working over into the bearings. A galvanized iron trough was easily attached to the framework of the machine, so that the slots permitted the lower roller to dip into the varnish about an inch.

An air-drying, core-plate varnish, made by Sherwin-Williams Co., is used and the discs are passed through the rolls before punching any holes or slots. They dry almost immediately, and the job is very satisfactory in every way. The machine is used for applying core-plate varnish to the laminations of small transformers, magnet cores, armature and core discs.

Honesdale, Pa. J. M. WALSH.

Construction of Low-Voltage Transformer for Testing

A HEAVY electric current will often be found very useful around an electrical repair shop for testing series coils, blowing out grounds and for many other purposes. The accompanying illustrations show the general design and construction of a small transformer which was built for use in our shop and has been found to be very serviceable. The cost was small and this transformer will deliver from 500 to 1,000 amp., at low voltage when operated on a 220-volt primary supply.

As shown in Fig. 1 (A) the laminations are 10⅜ in. long and 8½ in. wide with slots for the winding. The laminations are stacked 5 in. high.

The primary winding consists of 448 turns of No. 15 s.c.e. wire with a tap brought out at each 112 turns. This winding was wound on a simple wooden form, then taped, dipped in insulating varnish and baked.

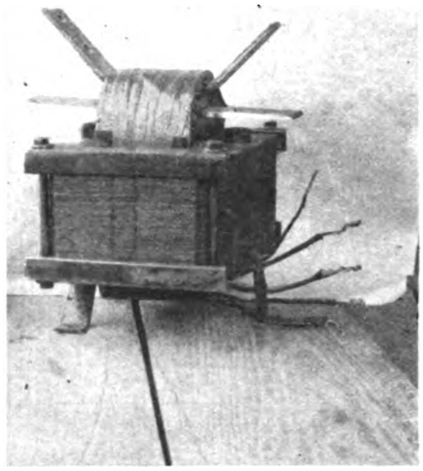


Fig. 2—Complete transformer after assembly.

The primary winding has 448 turns of No. 15 s.c.e. wire with a tap brought out at each 112 turns. The secondary winding consists of four strips of 20-mil copper each of which is wound around the primary a different number of turns. Short pieces of busbar copper were sweated to the strips to serve as terminals. By connecting the test leads to the different terminals, a comparatively wide range of voltage can be obtained, as shown in the table below.

Secondary Voltages Obtained on 220-Volt Primary

Connections: Primary	Connections: Secondary	Secondary Voltage*
A to B	L to M	2
A to C	L to M	1
A to D	L to M	2/3
A to E	L to M	1/2
A to B	L to N	4
A to C	L to N	2
A to D	L to N	1 1/3
A to E	L to N	1
A to B	L to O	6
A to C	L to O	3
A to D	L to O	2
A to E	L to O	1 1/2

*If 110 volts are used on the primar divide the secondary voltage by 2.

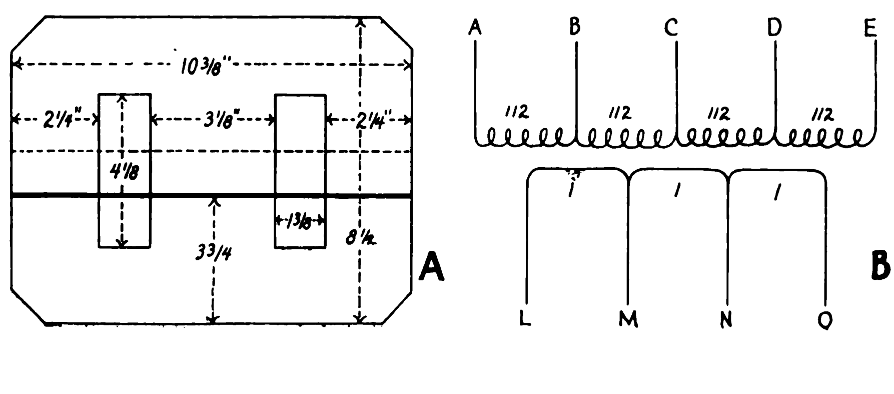


Fig. 1—Dimensions of laminated core of transformer, A, and ratio of turns in primary and secondary windings, B.

The secondary winding consists of three turns of laminated copper wound around the primary coil by hand and tapped at every turn. A short piece of ¼-in. by 2-in. bus copper was used as a terminal. To the end of this, four strips of 20-mil copper 3⅞ in. wide were securely sweated and one complete turn was made around the primary coil. Then another piece of ¼-in. by 2-in. bus copper was soldered on and one of the 20-mil sheets cut off. The three sheets remaining were carried around for the second time using 1/32-in. fibre as insulation and sweated to a third piece of bus copper. Then another sheet was cut off leaving two sheets to go around for the third time. The ends were then soldered to a fourth piece of copper for the end of the winding. The ratio of the turns in the winding is shown in Fig. 1 (B). Inasmuch as both primary and secondary windings of the transformer are tapped, a number of voltages are available as shown in the table. If still lower voltages are desired, 110 volts may be used on the primary and the table voltages halved.

The whole winding was then stacked into the iron, suitable insulation being provided and arrangements made for tapping off flexible leads. The laminations are firmly held together by clamping them between short pieces of light angle iron placed at the end. The complete transformer, shown in Fig. 2, is rather heavy and may be mounted on a small truck or dolly in order that it may be moved easily about the shop.

Using leads (L) and (O) on the secondary, the copper will carry 500 amp. If (L) and (M) are used, 750 amp. can be obtained, and with (L) and (N) 1,000 amp. These are, of course, intermittent ratings.

Detroit, Mich. H. B. WILLMOTT.

Simple Tool for Starting Screws in Inaccessible Places

WHERE a small screw or bolt is to be started, especially in an out-of-the-way place, it is often difficult to manage the screw, one's fingers and a screwdriver at the same time.

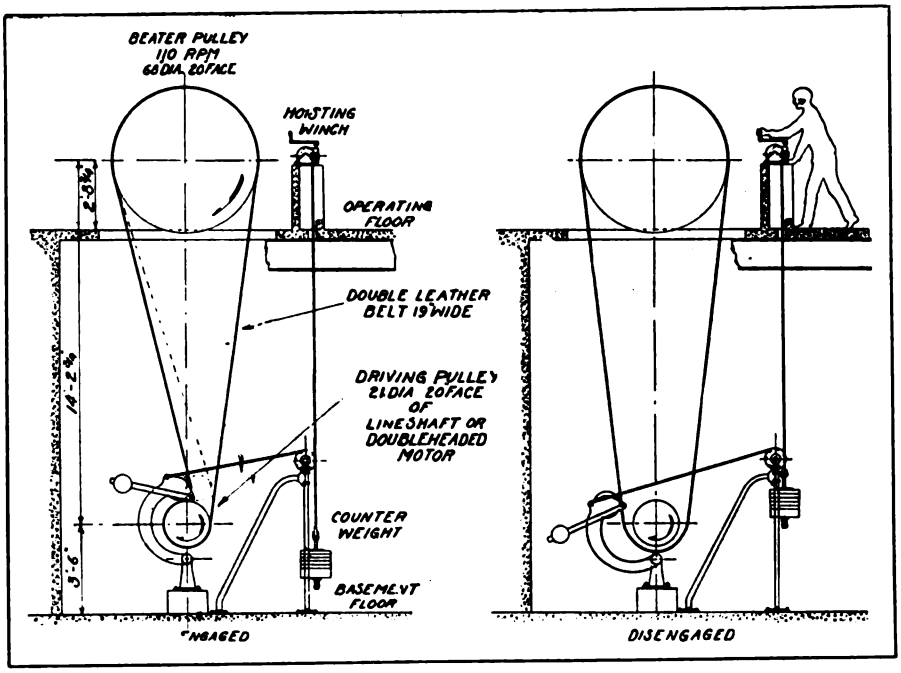
A simple tool which will save much time and trouble and be a boon companion for many repair men can be made from a piece of No. 10 iron wire cut to any desired length, one end of which is made fast in a suitable handle, the other end being slotted with a hacksaw. Two short pieces of clock spring should be inserted in this slot. After the springs have been shaped to fit the shaft and bent so that the outer ends are separated, the jaws of the slot should be mashed down on them and then soldered to hold them in place. This tool can, of course, be made in several sizes for different work.

In operation, the springs are pinched together and inserted in the slot of the screw or bolt. The springs will hold the latter until it can be started; the screwdriver may then be used to tighten it if necessary.

Goldfield, Nev. PHIL D. COMER.

Increasing Arc of Contact of Belts

(Continued from page 422)



This shows how the drive is used as a method of control.

Here a paper mill beater is driven by a lineshaft direct connected by a coupling to a motor located on the floor below. The beater is controlled when engaging or disengaging by the belt wrapper as shown, without stopping the motor. Ordinarily vertical drives are not feasible because of the likelihood of the belt sagging from the lower pulley because of its own weight. When this type of drive is engaged, sufficient tension can always be maintained on the belt to prevent slipping. This is also true if the small driving pulley is placed above instead of below.

heavy-duty compressors installed by one company in a number of its branches in various cities. Here the drive is used as a friction starting and cut-off coupling. In this case instead of installing slip-ring motors to provide for the heavy starting duty, four squirrel-cage motors with their higher efficiency, lower cost, and greater ruggedness of design are used. Before starting the compressors, the pulley of the idler is disengaged from the belt by lifting the counterweight. The squirrel-cage motor attains full speed in about 15 seconds and the counterweight is then lowered slowly, which causes the belt to pick up the load gradually. While starting, the belt does not remain long enough in contact with the rapidly moving pulley to become burned or even unduly worn before the counterweight is applied and the load picked up.

Many of this type of belt-wrapping drives are installed in paper mills where the big problem is to start heavy machines under load without using an extra-large or heavy-duty motor. This is met by connecting more than one machine to each motor, by first starting the motor and then cutting the machines in one at a time.

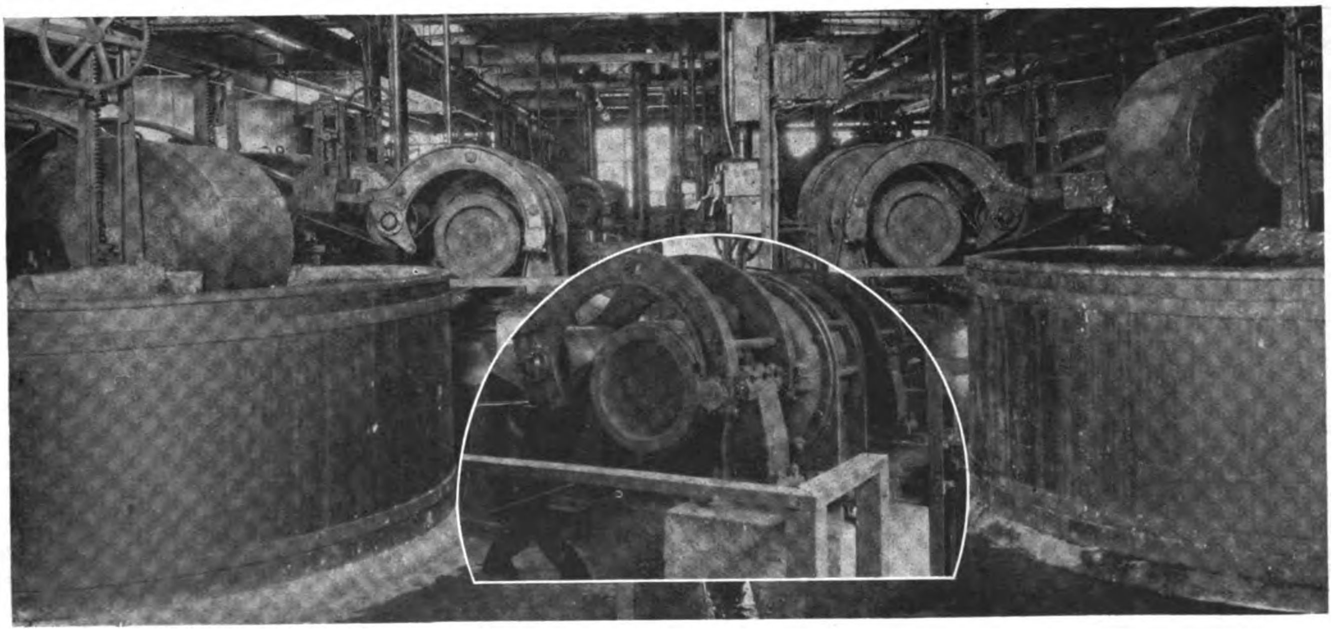
It is claimed that a drive of this special belt-wrapping type eliminates about 75 per cent of non-productive tension which would be necessary in many of the open drives with small arcs of contact. This type of drive may be used on the tight side of the belt if necessary, but it is preferable to place it on the slack side whenever possible. Also while it may be used on quarter-turn belts, a belt-wrapping drive cannot be used on crossed belts.

One point to be considered in all cases is that the type and position of any mechanical or other devices in power transmission service must be suited to the operating conditions, to insure satisfactory results.

[NOTE: Special acknowledgment is given to Benjamin F. Clark, an engineer associated with F. L. Smidth and Company, 50 Church Street, New York City, for supplying information, photographs and sketches which were used in the preparation of this article.]

Another interesting drive where two machines are driven from one motor.

This illustration shows fourteen paper beaters driven by seven 100 hp. double-headed motors. In driving two machines it is not possible to adjust the motor so as to take care of uneven stretch or tension in the two belts. The special drives, one of which is shown in the insert, take care of it. In some cases, vertical drives with the motors on the floor below are preferred on beater installations, as is shown in the line diagrams at the top of the page.



Trends in Steel Mill Operation

(Continued from page 416)

repairs. (2) Considerably less commutator wear. (3) Reduction of band breakage. (4) Less pinion maintenance. (5) Reduced expense for inspection and lubrication. (6) Less delay time charged against the operating department.

A number of the motor builders are equipping or will, on special order, equip motors with ball or roller bearings. Also, a great deal of attention is being paid to standardizing the sizes of ball and roller bearings for use on steel-mill motors so that all makes of bearings will be interchangeable.

On the other hand, there are those who say that some attempt should be made to improve the sleeve bearing before it is discarded for the ball or roller bearing. The main fault of the sleeve bearing has been oil trouble; that is, oil leakage with consequent short bearing life and winding troubles. One motor manufacturer reports improvements to the bearings used in its motors that render them leakproof. This being the case, the sleeve bearing cannot be said to be entirely out of the running, for it has many inherent advantages that appeal to operating men.

Considerable interest is being shown in the use of high-pressure lubrication. So far, this has been principally used on cranes, although there is no reason why it could not be applied elsewhere in the steel mill. The advantages causing this trend towards the use of high-pressure lubrication are said to be: (1) Keeps dirt out of grease cups and bearings. (2) Stops oil splashing. (3) Results in more uniform lubrication and fewer dry bearings. (4) Hence, it gives a longer bearing life.

At one plant high-pressure lubrication was put on a crane because the crane vibrated so much that it would shake off the caps to the grease cups; that is, they would unscrew due to vibration, and fall off. Then, too, the crane was in a very dirty location and each time grease cups were filled, more or less dirt got into the cups which would eventually work into the bearings. The high-pressure grease nipples installed did not shake off and, of course, the use of the grease gun prevented dirt from getting into the bearings.

An increased use of arc welding is now found in steel mills. Plants which have experimented with welding equipment have added more, and other plants have begun to use it. In the majority of the large plants, however, it is firmly established and from all reports is creating large savings in time and money. One small plant not yet using arc welding reports the use of $31,000 worth of gas a year for oxy-acetylene welding. Where gas is used in such quantities, the possibilities of arc welding in the steel industry become apparent. Two plants report savings of $400 on one job alone, over the cost of the repair methods previously used as compared with arc welding.

More and more interest is being shown in the type of welding electrode used. Various kinds of coated rods are being employed. A tapered welding rod has appeared on the market, the idea being that as the work heats up, the size of the rod becomes smaller as used.

Sheet-Mill Roll Heaters and Magnetic Rollers

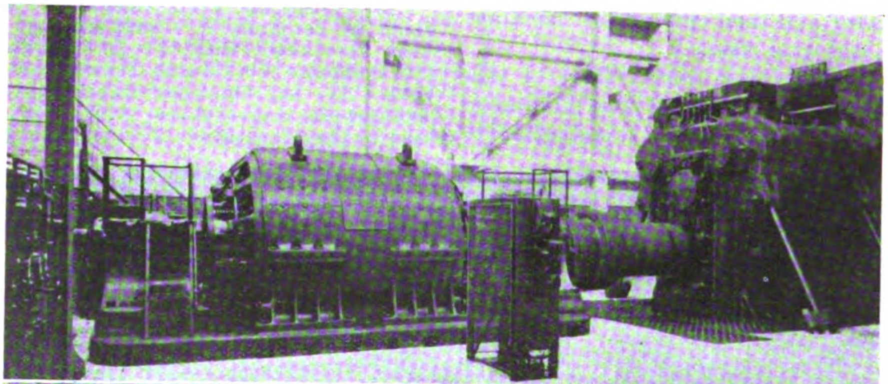
Increased use of electric roll heaters for preheating sheet mill rolls is reported. It is stated that this method of preheating rolls increases output and reduces roll breakage.

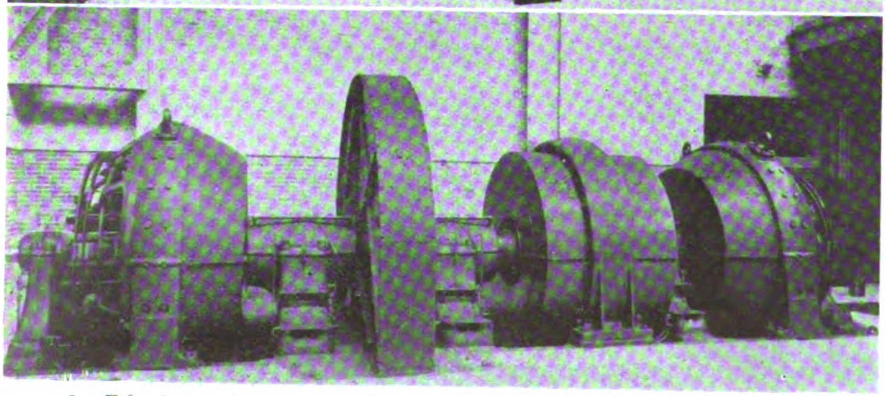
Recent installations have been made of magnetic rollers on roll tables, and an illustration of one installation is shown on page 415. The magnetic roller utilizes the tractive forces of the electro-magnet to increase the co-efficient of friction between the surface of the roller and the piece being conveyed. It is said that when using magnetic rollers the number and diameter of the rollers for a given length of table can be reduced, thereby requiring less driving power and consequently a smaller motor.

Electric Precipitation of Dust in Blast-Furnace Gas

An outstanding trend is the use of electric precipitators for the precipitation of the dust in blast-furnace gas. With the installation that has been completed during the past year at Pueblo for the Colorado Fuel and Iron Company, there are now three installations operating in the United States. There are several installations in Europe. Precipitators are now being built on a standardized plan whereby several small units take the place of a few large ones. These units are fabricated in the shop and erected there ready to be set up without considerable field erection. The installations that have

Reversing skelp-mill drive installed at the plant of the Youngstown Sheet & Tube Company, Youngstown, Ohio.
The upper illustration shows the 4,000-hp., 80/135-r.p.m., motor driving the main rolls. In the lower illustration is shown the flywheel motor-generator set. At each end of the set is an 1,800-kw., 650-volt, direct-current generator. In the center is a 39-ton flywheel and a 2,500-hp., 6,600-volt induction motor.





been made are reported to be operating successfully. Considerable interest is being shown by a number of the steel plants.

The advantages claimed for the electric-precipitation process are: (1) It saves the heat content in the gas, for the gas is not cooled by this method of removing the dust. (2) There is no water to pump, which saves power and maintenance expense. (3) The gas pipes never require cleaning as is the case in some other methods of dust removal. (4) The dust precipitated has a value—in some localities it may pay the cost of operation of the precipitator. (5) Results in improved boiler efficiency and consequently gives more power from the same amount of gas and cuts down the amount of coal that must be burned to supply the power required in addition to that furnished by the blast-furnace gas.

Safety Practices Are Becoming Standardized

Steel mills are much in advance of other industries with regard to safety work. Their safety work is getting to the point where it is more or less standardized. When buying new equipment special attention, however, is paid to its design so that it is inherently safe. A safety device that is added to a machine and retards production is no longer looked upon as being a true safety device.

Many plants, particularly those that were built prior to the time that safety work reached its present development, are actively engaged in making their mills safer. Electrical apparatus is either being enclosed or surrounded with safeguards, the general idea being to make it impossible for the mill workers to touch a live part. Particular attention is being paid to cranes in the older works; dependable limit stops and safer enclosed-type controllers are being added. Stairways are used wherever possible, to the exclusion of ladders.

In many plants special attention is being paid to the proper grounding of electrical apparatus. Switchboxes, cutouts, safety switches and conduit systems are carefully grounded, the general trend being to ground everything electrical that the workman can come in contact with. Included in this are portable tools, such as portable drills, portable electric winches, extension lights, etc. One plant is grounding the cases of such tools, using a three-wire cable and polarized plugs, the third wire being the ground wire which is solidly grounded through one terminal of the polarized plug.

More attention is also being paid to the matter of the repairman locking a machine so that it cannot be started while under repair. One plant is installing a safety switch beside each of the auxiliary motors on the mill floor, the idea being that the repairman working on a particular motor or the apparatus that it drives, will make no mistake in selecting the switch to open and thus kill all circuits right at the motor. He can lock this switch open with his own padlock.

During the recent slump in the steel industry, many plants instead of laying off their entire force and locking up the gates are taking advantage of the lull in operations to make extensive repairs to their equipment and men who might otherwise be forced into idleness are kept at work in this way. Other plants are making extensions or replacements.

It is becoming the policy of more and more companies to keep their plants abreast with new developments, so as to meet competition at all times. In pursuit of this policy, some works are not sparing expense to keep their equipment ready and fit for profitable operation when the predicted period of business revival will call for production at an increased rate.

Editor's Note: Special acknowledgement is made to *The Iron Age* for the illustrations on pages 408 and 415 and also to the Allis-Chalmers Manufacturing Company, the General Electric Company and the Westinghouse Electric and Manufacturing Company for data and illustrations used in this article.

Changing a Steel Mill Drive

(Continued from page 427)

The principal reason for this is that the coefficient of friction, between the shaft and bearing metal, varies inversely as the pressure, consequently within certain limits the coefficient of friction increases as the weight on the bearings is decreased. A considerable portion of the babbitt should have been removed from the bearings. This has not been done as yet. This was the last important change made.

Some problems of lesser importance presented themselves during this time. The mill-motor armature coils were connected to the commutator bars by copper risers, about 12 in. long and ¾ in. wide. Some of the risers broke off directly above the commutator bars. An acetylene torch with a special tip was used to provide a very thin hot flame, the broken risers were removed, and new ones inserted, without removing either coils or bars. A second row of twine lashing was then put on, to prevent the vibration of the risers at this point.

The mills are not reversed, except to run the gears reversed to increase their life. Some complaint was made about the creeping of the motors between operations. This creeping is due to the residual magnetism in the generator and motor fields, which provides sufficient torque and current to cause the motor to creep. In most cases the creeping is a benefit, as it allows a better distribution of cooling water on the rolls, but sometimes it is necessary, for safety reasons, to stop the mill entirely. This is done by the remote-controlled circuit breakers, purchased with the new equipment, and shown in Fig. 4. A contact in the master controller prevents the closing of the breaker when the voltage is built up on the main generator.

The equipment as now arranged gives good service, with a minimum of trouble, and its flexibility is considerably greater than two large motors would be. When the trouble occurred with the generator coil referred to one of the motor-generator sets driving the combination on the roughing mill, was put out of commission for nearly a week while the generator armature was being repaired. The cables were connected so as to run the two motors on the roughing mill from one generator, and a resistance equal to that of the shunt field of the disabled generator was connected in the field circuit of the good generator. No other changes in control were necessary. The mill was run as usual, except at exactly half speed. The torque, much to the surprise of the mill crew, was as great as before, and as the time of rolling on the roughing mill is not the limiting factor in production, very little, if any, decrease in production resulted.

In case of trouble in any mill motor armature, it would still be possible to run both mills, as the three armatures are electrical duplicates.

The cost of the present installation was less than two large motors would be, especially if it had been necessary to change the foundations.

It is interesting to speculate upon the experience we would have had with a steam engine drive.

Laying Out Wave Windings

(Continued from page 435)

left-hand winding and a similar distance to the right for a right-hand winding.

Since, in Fig. 17 R_1 connects to a conductor in the bottom of slot *19*, then according to *Rule 8*, R_2 will lay in the bottom of a slot one front pitch to the left of R_1. Counting a distance equal to one pole pitch or six slots, we arrive at slot *13*. Therefore, the R_2 lead should lay in the bottom of slot *13*. Inspection of Fig. 17 will show this to be the case.

Rule 9.—The A_2 lead will be located in a slot that is one front pitch from A_1 measured in a counter-clockwise direction for a left-hand winding, and a similar distance measured in a clockwise direction for a right-hand winding.

Since this is a left-hand winding, we will count counter-clockwise a distance equal to six slots from slot *3* and we arrive at slot *21*. Therefore, A_1 is connected to a conductor located in slot *21*. Inspection of Fig. 17 bears this out.

Rule 10.—If A_1 connects to a top conductor, then A_2 will connect to a top conductor, or vice versa.

Inspection of Fig. 17 shows that both A_1 and A_2 connect to top conductors.

There are four possible locations for the beginning of the second phase. They are slots *6*, *12*, *18*, and *24*. With the above rules in mind, we will try each different location so as to secure the best position. We will first try slot *6*. The end of the first section which in the other phase was called R_1 we will call R_3 in this phase. According to *Rule 7*, R_3 will be $6 + 3 - 1 = 8$ slots measured in a counter-clockwise direction from B_1. Counting in a counter-clockwise direction from slot *6*, we arrive at slot *22*, which is the location of R_3. According to this same rule since B_1 (corresponding to A_1 for the other phase) connects to a top conductor, R_3 will connect to a bottom conductor. The start of the second section of the phase which corresponds to R_2 of the same point in the first phase, will be called R_4. According to *Rule 8* and since R_3 connects to a bottom conductor, R_4 will connect to a bottom conductor. According to the same rule R_4 will be located one front pitch measured in a counter-clockwise direction from R_3. Since R_3 is located in slot *22*, we wiii count six slots in a counter-clockwise direction and arrive at slot *16* which is the location of R_4.

Similarly, according to *Rule 9*, the B_2 lead will be located in slot *24*, that is, a distance of six slots or one full pitch measured in a counter-clockwise direction from slot *6*, which is the location of the B_1 lead.

Examination of the location of the B_1, R_3, R_4 and B_2 leads will show that they are interlaced with and crossed with the *A* phase leads. A similar check will show that if the B_1 lead were located in slot *24*, we would still have the same interlacing. However, by further checking we find that if we use slot *18* for the B_1 lead, we will do away with this interlacing. Using slot *12* for the B_1 lead would interlace the R_4 and R_2 leads with the A_1 and R_1 leads. Consequently, the best location from the interference standpoint is to start the *B* phase in the top of slot *18*. On the other hand, if this were a large machine and if heavy conductors were used, it might be better to select the start of each phase in a manner that would bring the A_1, A_2, B_1 and B_2 leads close together and to the point where they leave the machine.

Fig. 18 shows the first series of coils in the first section of the *B* phase drawn in. Starting B_1 in the top of slot *18*, we find that B_2 will be in the top of slot *12*, R_3 will lay in the bottom of slot *10* and R_4 will fall in the bottom of slot *4*. These conclusions are arrived at in a manner similar to that outlined in *Rules 6* to *10* inclusive.

Fig 19 shows the first section of the *B* phase completed. Fig. 20 shows the winding complete. The asterisks show the location of the short front pitch coils. Figs. 11 to 20 explain and illustrate the application of the rules for constructing a wave-winding diagram for two-phase stators having two-layer windings.

Figs. 21 and 22 show how a wave winding would be laid out for a four-pole, single-phase motor having sixteen slots and sixteen coils.

In a succeeding article will be explained the construction and rules as applied to a three-phase winding of this type.

Maintenance and Repairs

(Continued from page 437)

article, is wisely fostered and the difference between it and Repairs is made clearer than has been the case in the past, undoubtedly there will be greater efficiency all around which will manifest itself in the one way that really counts—increased production at reduced costs.

Efficient maintenance requires constant watchfulness and alertness, the closest attention to everything that is taking place in the plant, and a staff of loyal and efficient foremen who can be imbued with the right ideas on this all-important question only if supported by an enthusiastic chief and the confidence of the management—and most managements are enthusiastic on the subject.

Pacific Coast Lumber Industry

(Continued from page 407)

day. The kilowatt-hour consumption will vary from 10 to 20 kw.-hr. per thousand board feet, depending upon the character of the timber, and will average about 15 kw.-hr.

Saw mills and lumber products plants are also electrified to a large extent. The high speed of woodworking tools and the dust constitute the main problems in woodworking plants. These conditions have led to the use of ball-bearing motors and, with many finishing machines, multi-motoring with separate motors, all controlled as a unit, driving each tool. According to the 1921 figures compiled by the Statistical Department of the McGraw-Hill Co., the woodworking plants consumed 810,000,000 kw.-hr. of electrical energy. There are about 69,000 motors in this industry rated at 785,963 hp. Of these motors 25,400 are rated as under 5 hp. Of the total number of motors it was estimated at that time that 50,449 are operating belt drives, 2,678 chain drives and 15,830 are direct connected.

The total value of lumber and lumber products produced in the United States, according to the 1921 Census, was about $900,000,000. The total value of the products of the woodworking industry was almost $2,430,000,000, which indicates the large increase in value through manufacture.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

The Paine Company, 2951 Carroll Avenue, Chicago, Ill.—A loose-leaf catalog lists and illustrates the Paine toggle bolts, expansion shells for bolting to floors, walls or ceiling by an expanding nut, outlet box and fixture hangers, star drills, perforated strap-iron hangers, hanger rings, screws, nuts and bolts, sprinkler-pipe hangers and ceiling plates, malleable pipe rings and turned eye U-hangers. Some of these applications are illustrated. This company also manufactures and markets a special tapping machine with a capacity up to 20,000 irregular shaped nuts a day.

Janette Manufacturing Company, 556-558 West Monroe Street, Chicago, Ill. Bulletin on "Special Small Motors" illustrates a wide variety of designs of direct- and alternating-current motors of 1/20 to 1/4 hp. rating and shows some of their many applications, including their use on adding and addressing machines, oil burners, textile machinery, liquid-mixing equipment and so on. These motors are all designed and built for a particular service or with special reference to the equipment they are to drive. Particular attention is called to a new type of self-aligning sleeve bearing which allows slight bending of shaft under load.

Carr Fastener Company, 31 Ames Street, Department E, Cambridge, Mass.—A booklet entitled, "Better Lubrication for All Machinery," describes the operation and advantages of the Dot high-pressure lubricator, its attachments, applications and a large list of users.

Mica Insulator Company, 68 Church Street, New York, N. Y.—A booklet entitled, "Commutator Insulation and Assembly," discusses the type and hardness of different kinds of mica, commutator segment insulation and "Micanite" which is a built-up mica sheet. A number of other pages discuss the application of "Micanite" and some of the commutator troubles which are often attributed to mica.

Allan Manufacturing and Welding Company, Inc., 726 Washington Street, Buffalo, N. Y.—Announcement is made of a 120- or 220-cycle welding generator suitable for any power installation. This is brought out as the result of the experience of this company in which they claim that in many welding undertakings alternating current gives better results with cast and malleable-iron and good results with steel and iron. The generator may be driven by either belt, alternating or direct current motors or gasoline engines and is built in any desired capacity.

Cote Bros. Manufacturing Corporation, 1425 First National Bank Building, Chicago, Ill.—A folder describes the "Simplicity" refillable plug type fuse which consists of only two parts, and a small refilling fuse.

Dodge Manufacturing Corporation, Mishawaka, Ind. — Literature announces a new lineshaft hanger bearing embodying the Timken tapered roller bearing as well as several new features of construction. There are only five parts, including two Timken tapered roller bearings, to the complete assembly, and they may be used on any commercial shafting. Special lubricating and dust-proofing features are embodied in the design.

General Electric Company, Schenectady, N. Y.—New index lists of G-E publications are listed in the following booklets: Y-1,991—"Index to Descriptive Publications;" Y-1,992—"Index to Supply Parts Bulletins;" Y-1,993—"Index to Instruction Books and Cards."

Charles Bond Company, 617-619 Arch Street, Philadelphia, Pa. — Booklet G illustrates and lists the popular Bond transmission specialties, such as steel and cast-iron hangers, pillow blocks, solid and split safety collars and compression and clamp couplings.

The Thompson Electric Company, 226 St. Clair Avenue, N. E., Cleveland, Ohio—A folder entitled, "Why Not Get the Benefit of the Light You Pay For?" shows the advantages of the Thompson safety disconnecting hangers and how they enable users to get full value from lighting because they make cleaning easier.

A. Leschen and Sons Rope Company, St. Louis, Mo.—A booklet entitled "Practical Information on the Use and Care of Wire Rope," shows how wire rope is spliced, lubricated, how to apply clips and sockets, how to determine stresses and facts about ordering.

Despatch Manufacturing Company, Minneapolis, Minn.—A special bulletin describes a portable coil and armature baking oven which is designed to overcome the necessity of heating a large oven for a small amount of baking. The ventilating system preheats the cold air as it enters the bottom of the oven. Air drying and rotation of coil are recommended before inserting in the oven.

Bussman Manufacturing Company, 3819 North Twenty-Third Street, St. Louis, Mo.—Catalog 12 of Buss products includes a simple non-technical treatise on fuses and their use. This gives in twenty-four pages a complete discussion of the operation of fuses and how they protect equipment.

The American Resistor Company, Cold Spring and Eleventh Street, Milwaukee, Wis.—Announcement is made of a change of name of this company, formerly known as the Wireless Resistor Company of America. A booklet entitled, "Stories of the Globar Element," shows the origin of this non-metallic electrical heat unit for industrial and domestic use and gives some of the important advantages of it. A special chart shows the current values of globar heating element and the range and watt limit in relation to length.

John Dolph Company, 168 Emmet Street, Newark, N. J.—A folder discusses the effect of lubricating oil upon insulation. Dolph's electric lacquer, it is stated, is both oil and waterproof and will protect and preserve insulation and so prevent breakdowns which might result from oil or water.

Ramsey Chain Company, Inc., Albany, N. Y.—A booklet entitled, "Power Transmission with Ramsey Silent Chains," shows the advantages of silent chain transmission and its field and application in industry by discussing the various types of drive to which it may be applied. Considerable space is given to tabulation of data on sizes and capacity as well as suggestions for applying them to particular work.

Miniature Breaker Company, Inc., 200 Fourteenth Street, Long Island, N. Y. —A folder describes the Minibreaker, a small circuit breaker for small alternating-and direct-current motors, which are claimed to give 100 per cent automatic protection without fuses.

Mid-West Air Filters, Inc.—Department F-18, 100 East 45th Street, New York, N. Y.—Data-book B, entitled, "Air Filters for Compressors and Internal Combustion Engines," describes the construction and operation of the Mid-West air filters and gives a large amount of data and methods of calculation required in determining the capacity of a filtering installation.

Standard Conveyor Company, North St. Paul, Minn.—A circular entitled, "Overhead Stands Still," shows by illustration and text how a number of companies have reduced their material handling costs by using standard conveyors. These applications show a wide variety of installations and types of work handled.

The Alexander Milburn Company, 1416-1428 West Baltimore Street, Baltimore, Md.—A folder entitled "The Milburn Light" describes the various types of portable Milburn carbide lamps which may be used for engineering construction, mine work, yard work and other night activities.

G & W Electric Specialty Company, 7440 South Chicago Avenue, Chicago, Ill.—Bulletin 231 entitled "Potheads and Accessories" covers the line of G & W distribution specialties. This includes single and multiple conductor potheads and disconnecting potheads as applied to inter-connected distribution systems. Such subjects as instructions for ordering, mechanical details, installation instructions, and standard applications are included. In addition to listing of types and prices, various other devices such as series cutouts, fuse blocks, conduit bells and caps are also listed.

R. W. Cramer and Company, Inc., 136 Liberty Street, New York, N. Y.—Circular A-3 describes the Sauter self-winding electric time switches which range from 2 to 300 amp. at 110-250 volts and 25 and 50 amp. for 3,000 to 6,600 volts.

The Hart Manufacturing Company, Hartford, Conn.—A manual of "Remote Control Equipment," shows the application of the Diamond H remote control switches for multi-circuits, no-voltage release switches, tank switches, relays and solenoid devices. This equipment may be used for extinguishing all the lights on the floor, even though they be lighted by separate switches, to control switches which transfer the connection from one power circuit to another in case of low voltage or voltage failure, and for numerous other uses as shown.

The Medart Company, Potomac and De Kalb Street, St. Louis, Mo.—Catalog 43 entitled, "Line Shafting Equipment," catalogs the entire line of power transmission equipment supplied by this company. This consists of lineshafts, hangers, couplings, pulleys, gears and various other equipment. Complete table comprising price as well as a large amount of data and a number of charts are included.

The Dayton Safety Ladder Company, Dayton, Ohio—A 12-page folder illustrates the construction and application of the Dayton safety ladder, which is a special stepladder of well braced and reinforced construction with a large working platform.

Diamond Saw and Stamping Works, Buffalo, N. Y.—Folders describe the various types and sizes of Sterling power hack saw machines which have an automatic lift to raise the blade on the return stroke.

Weston Electrical Instrument Company, 10 Weston Avenue, Newark, N. J.—A number of small booklets and circulars describe the various Weston portable and stationary testing voltmeters, ammeters and other testing equipment for garage and battery service.

The English Electric Company, Ltd., Queen's House, Kingsway, London, W. C. 2, England—Publication 471 describes the ironclad truck-type switchboard class OLZ and gives detailed drawings as well as illustrations showing how the board is constructed.

Thorner and Martens, 463 Commercial Street, Boston, Mass.—A portable test block, used to facilitate the testing of commercial sizes of incandescent lamps from the Mogul base downward, is only 3 in. square and 1¾ in. high overall with the test cord and plug for quick service. After plugging into an outlet, contact is made by touching one terminal of the device under test to a triangular brass base mounted on a micarta insulating block and touching the other terminal to either of two connected brass strips forming a "V" and mounted on insulated supports above the right and left-hand edges of the base piece.

Chicago Belting Company, 110 North Green Street, Chicago, Ill.—A 16-page booklet describes "pre-tested" leather belting, tells what it is, what it means to the buyer of belting and who makes it, with a brief history of the Chicago Belting Company. All users of leather belting will find this interesting.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—Circular 1670 entitled, "Static Condensers for Power Factor Correction," not only discusses power factor and its effect but also its correction and in particular compares the characteristics of static condensers and synchronous condensers in power factor correction. Anyone interested in power factor correction will find this 20-page booklet worth while.

Reeves Pulley Company, Columbus, Ind.—Catalog T-44, entitled: "The Reeves Variable-speed Transmission" illustrates the construction of this equipment and a large number of installations in various lines of industry. One particularly interesting page gives a list of the various types of machines on which variable speed transmissions are used in different industries.

Charles A. Schieren Company, 22 Ferry Street, New York, N. Y.—The first of a series of monthly issues on "Quality Facts About Belting," discusses the subject of "Choosing the Hide," the source of hides and the best type of hides to be used in leather belting. Upon request, anyone interested will be put upon the mailing list to receive the entire series, together with a loose-leaf binder for filing.

American Pulley Company, 4200 Wissahickon Avenue, Philadelphia, Pa.—A folder gives a description and dimensions of the new American pressed steel hanger and its bearings which are made to take shafts from 13/16 in. to 2 13/16 in. diameter.

Pawling & Harnischfeger Company, Milwaukee, Wis.—Bulletin 320 describes P. & H. Type U hoists, which are monorail units made for floor control or for cage operation. Both mechanical and electrical features are described in detail, together with dimensions and detailed specification of the several sizes.

Bond Foundry and Machine Company, Manheim, Lancaster County, Pa.—A folder describes the Bond anti-friction truck casters with double-ball swivel race and roller bearing wheel construction for medium and heavy duty. These may be provided with rubber tires if desired.

General Electric Company, Schenectady, N. Y.—Circular 67450.1, Class 1 describes the oil circuit breakers of type FK-132-A and FK-132-B with capacities of 7,500-15,000 volts and 400-1,200 amperes. Detailed illustrations show the construction of the various parts.

Gurney Ball Bearing Company, Jamestown, N. Y.—Engineering Bulletin M-1, entitled: "Gurney Ball Bearings in Electric Motors," is prepared to assist in the making of applications of ball bearings to electric motors. A number of different applications are sketched together with ball bearing recommendations for both horizontal and vertical motors. Several pages give additional related data.

Williams Tool Corporation, Twelfth and Liberty Streets, Erie, Pa.—A new catalog describes the portable type threading, cutting off and reaming machines marketed under the name of "Willie Williams," which are especially designed to permit being moved easily. Other catalogs describe the complete pipe equipment capable of taking pipe from ¼ in. to 24 in.

Metals Coating Company of America, 495-497 North Third Street, Philadelphia, Pa.—A 16-page bulletin describes the use of the MetaLayeR-Schoop process for spraying a metal coating of zinc, lead, aluminum, iron, tin, copper, bronze, brass, nickel or monel metal over surfaces to protect them against corrosion or acids and with aluminum for high temperature work.

J. H. Williams and Company, 1000 West One Hundred and Twentieth Street, Chicago, Ill.—A new catalog describes the Williams drop forged tools and forgings. These include wrenches, Vulcan chain-type wrenches and pipe vise mount and clamp and turning tool holder, together with miscellaneous drop forgings.

Detroit Electric Furnace Company, 2335 First National Bank Building, Detroit, Mich.—Bulletin 41 gives some interesting information in regard to the use of electric furnaces in brass melting and shows economies effected by it and how complete control of analysis, color, texture and homogeneity of the alloy is secured.

The Republic Rubber Company, Youngstown, Ohio—A 36-page booklet entitled "Republic Belting" describes and gives the recommended applications of the different grades of Republic transmission, conveyor and elevator belting, in addition to rules for belt application, points to be considered in the purchase of conveyor belting, care of conveyor belts, conveyor belt specifications, and other data and suggestions concerning the use of belts. Several pages are devoted to special belts for special purposes, such as acid-resisting belts, belts for tanning factories, concentrating mills, polishing, sanding and other purposes.

The Oil Conservation Engineering Company, Addison Road and New York Central Track, Cleveland, Ohio—A 24-page booklet describes the "Oceco" fire extinguishing equipment which consists of a ten gallon carbon-tetrachloride extinguisher which is particularly adapted for use in central station and industrial power and light plants, transformer stations, relay stations, booster stations, and storage battery stations as well as in connection with oil, waste, varnish and grease fire hazards and is non-freezing to 55 deg. F. below zero. This bulletin also describes an Oceco automatic sprinkler fire extinguisher for use in connection with agitators, especially those treating light oils.

National Carbon Company, Inc., Cleveland, Ohio—A new catalog in a special binder and not only devotes more space than ordinarily to carbon brushes but includes other carbon products and goes very thoroughly into the technical side of brush operation. Considerable space is devoted to the discussion of the physical characteristics of brushes, brush recommendations, how to order brushes, description of brush grades, special brushes, location at which shunts should enter brushes, standard shunts, standard terminals and cables and special data as to aid in the selection of brushes for special purposes.

Ingersoll-Rand Company, 11 Broadway, New York, N. Y.—Literature describes the new size D, light-weight, non-reversible pneumatic drill suitable for light drilling up to 9-16-in. and reaming up to 5-16 in. This tool is applicable to a wide variety of work in repair shops and manufacturing plants.

Founded 1882 as Electrical Review OCTOBER, 1924 McGraw-Hill Co., Inc., Chicago, Ill.

Industrial Engineer

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

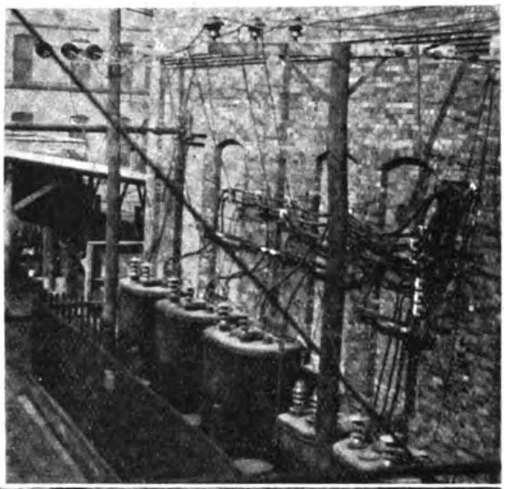
INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 82 Chicago, October, 1924 *Number 10*

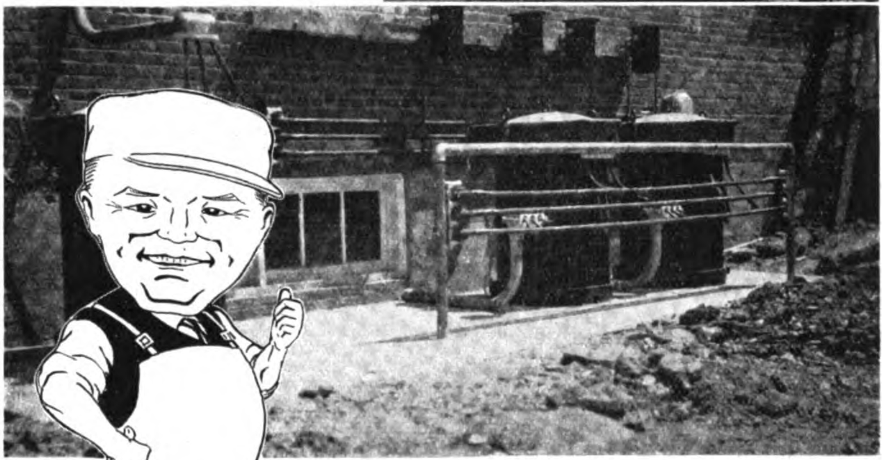
These Pictures Speak Louder Than Words—

One Job Shows That the Other Has Little Justification and How Easily It Could Be Revamped



NOT so long ago I was in Greenville, S. C., and called on my good friend, R. S. Huntington, who is president of Huntington & Guerry, one of the largest mill contracting firms in the South. R. S. H. is chock full of construction ideas and every time I see him he has something new to spring. Among the things he showed me this time was the arrangement of primary and secondary wiring for the small transformer substation shown in the accompanying photo. The idea is so good and so simple that I want to pass it on to those of you who may have an installation, such as shown in the upper photo, that has been an eyesore for a long time and you have not taken the time to revamp it.

Whenever I see an unsightly mess of outside wiring like that in the top photograph, I can't help but think of the grief some fellow may have after a heavy sleet storm trying to patch up a hopeless tangle of dangerous wiring. But the scheme devised by R. S. H. as shown here points a way to a real job that will stay put as long as the transformers will last. It will be noticed that the pipe frame anchored in the concrete foundation for the transformers, serves both as a guard and a means of drawing the primary bus cables up tight. The same idea is used for the secondary bus cables, so that connections to the primaries and secondaries of the transformers are flexible yet rigid enough to withstand the severest strains that may be caused by storm, snow and sleet. Note also that conduit is used as far as possible and that it is supported in a permanent fashion so that no wires are left dangling to be whipped about and finally broken.



It's perhaps unnecessary to compare these two installations since they speak for themselves. The one is a fine looking job and the other a dilapidated mess of wiring, the like of which can be found too often at the rear of a plant where few people see it. If you have such an eyesore, I hope this idea of R. S. H.'s will inspire a cleaning-up job. Sometimes all that is needed is a suggestion like this and a free Saturday afternoon or Sunday to give a new birth to a job that has been in mind for a long time. If these photos do cause such action and you work out a good looking job, take a picture and send it to me with or without a picture of what it looked like before you started. Or if you have already devised a scheme similar to that of R. S. H.'s, send that along and let me show you how you yourself can get some credit for an original idea and the ambition to do good housekeeping around your plant. You can't afford to give the impression that messy wiring and sloppy patchwork represents the kind of thinking you do. On the other hand, good installations well kept up are a just cause of pride and good insurance against unexpected failures and the grief that goes with them.

Practical Pete

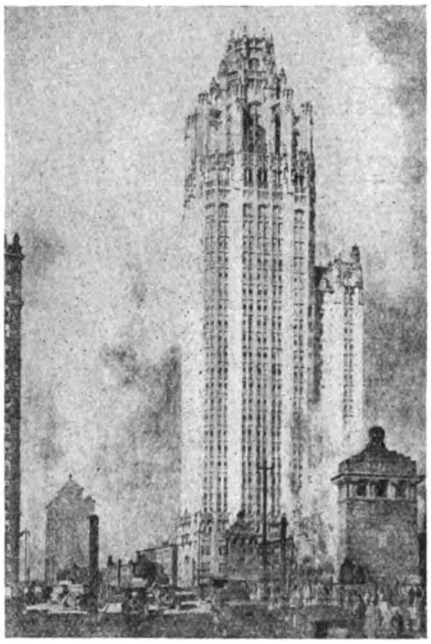
A Glimpse into the Plants of

The Chicago Tribune Company

Which publishes and delivers over 600,000 copies daily and 900,000 copies on Sunday in Chicago and over 800,000 copies daily and Sunday of the Daily News in New York, as well as 600,000 copies of Liberty, a weekly magazine

ONE OF the best examples of the value of giving careful attention, inspection and maintenance lies in the printing presses of our metropolitan daily newspapers. In order to get papers on the street and in the mail at fixed times and still report the late news, presses must operate against a very close schedule. Between runs the press is gone over carefully so that it is ready to go without interruption when once started.

Other complicated mechanisms in connection with a large publishing establishment are the linotype and monotype machines, which set and cast type mechanically by the operation of a keyboard, and the machinery for paper production. The accompanying illustrations give some idea of their size and complexity.



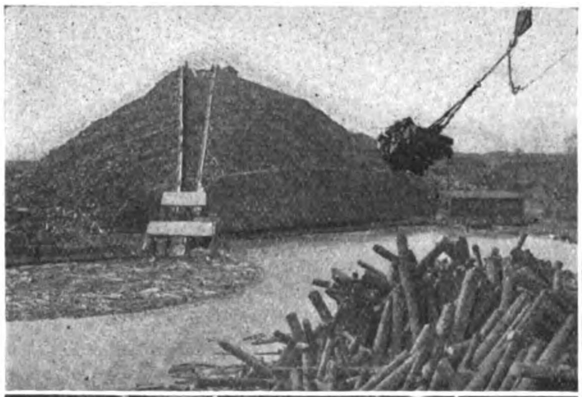
This will soon be the new home of The Chicago Tribune.

Tribune Tower is now under construction and will be occupied early in 1925. This is the design which won the $50.000 prize in a competition among the world's architects. The building will rise 456 feet above Michigan Blvd. Some of the presses are already installed and the building is being constructed around them.

Newspapers have become such a daily institution as to be regarded almost as a necessity. Statistics show that at the end of 1923, there were 426 English-language morning newspapers with 11,500,000 circulation, 1,610 evening papers with 20,000,000 circulation and 547 Sunday papers with 21,500,000 circulation. In addition, a large number of semi-weekly, weekly and more or less frequent local newspapers are published.

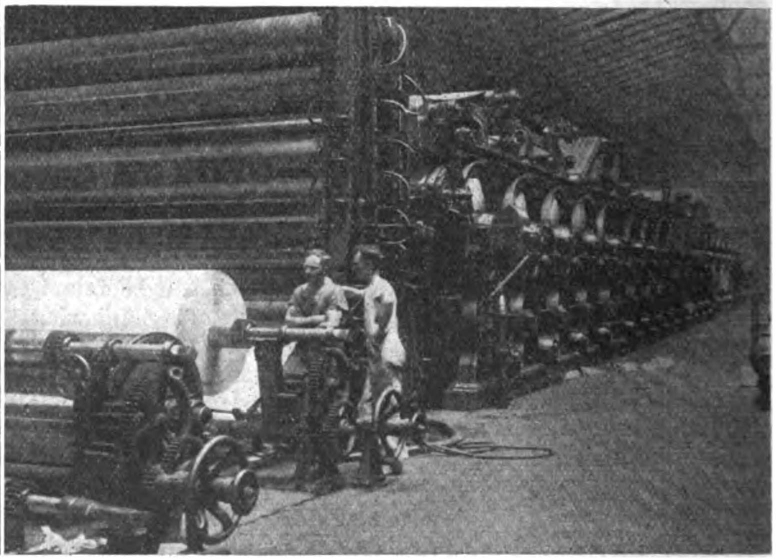
One of the largest newspaper plants in this country is operated by The Chicago Tribune Company, Chicago, Ill., publishers of The Chicago Tribune, the Daily News (New York City) and Liberty, a weekly magazine. Each of the two newspapers has the largest morning circulation in Chicago and New York, which totals 1,400,000 copies daily.

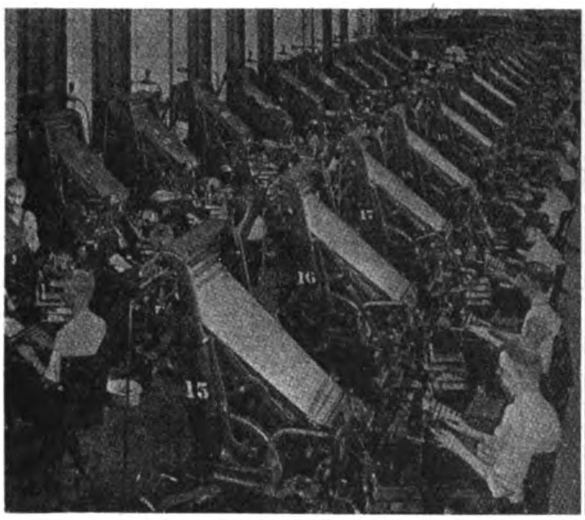
The Chicago Tribune was first published in 1847 when Chicago had a population of 16,000 and only one railroad. Since then it has missed publication only four times—two days due to a fire in 1849 and two

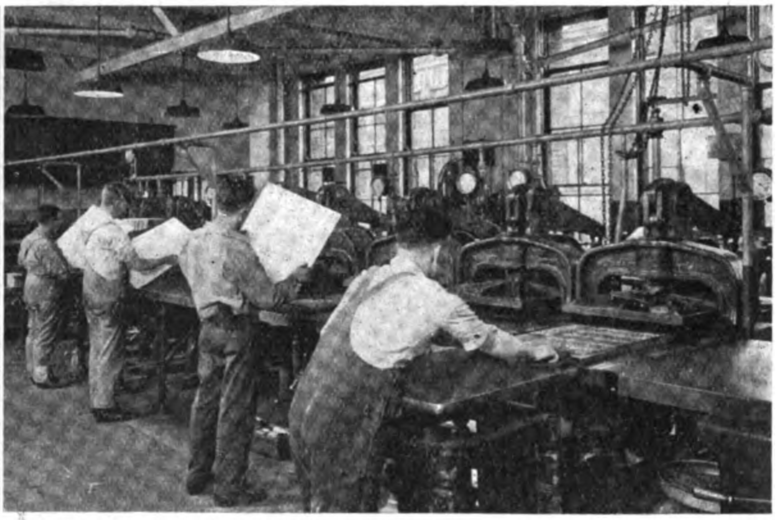


Steps in the making of paper for The Chicago Tribune and the New York Daily News.

The Chicago Tribune Company has 500 sq. mi. of pulp land far up on the Gulf of St. Lawrence. This timber is cut in winter and floated down to the Gulf in the Spring where it is loaded on boats and hauled down to the paper mill at Thorold, Ontario, near Niagara Falls. The illustration at the left shows how the logs are lifted from the deck of a steamer and thrown into the pond at the paper mill. They are floated across the pond, sawed into 4 ft. lengths, and then built up into huge storage piles. One of the first steps in the making of paper is grinding the pulp wood. The workman (lower left) is inserting a log into a grinding machine. Below is part of the paper mill for making newsprint.







The linotype room and the matrix tables.

This is part of the battery of 59 linotype machines used in the plant of The Chicago Tribune. Here each line of text is cast on a slug. As the operator touches the key board the machine selects the proper letters from the magazine, places them in sequence, automatically equalizes the space between the words, casts the words in a slug of a single line, and then distributes the original type mold or matrix back into its proper place in the magazine to be used again. After the reading matter is assembled into pages, along with the advertisements, the whole is locked into a steel form and brought to the matrix tables shown at right. Here a thick mat, made up of several thicknesses of special paper, is placed on top of the type and a pressure of 15,000 lb. applied. This impression forms the molds for casting the stereotype plates, which are used in printing.

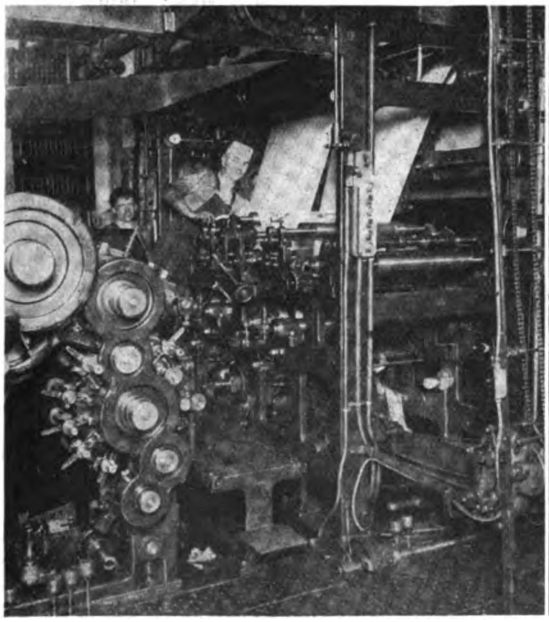
days at the big Chicago Fire in 1871, both of which destroyed the entire plant. But the growth during that time has forced the Tribune to move into larger quarters several times. It is now building a complete new office building and publishing plant.

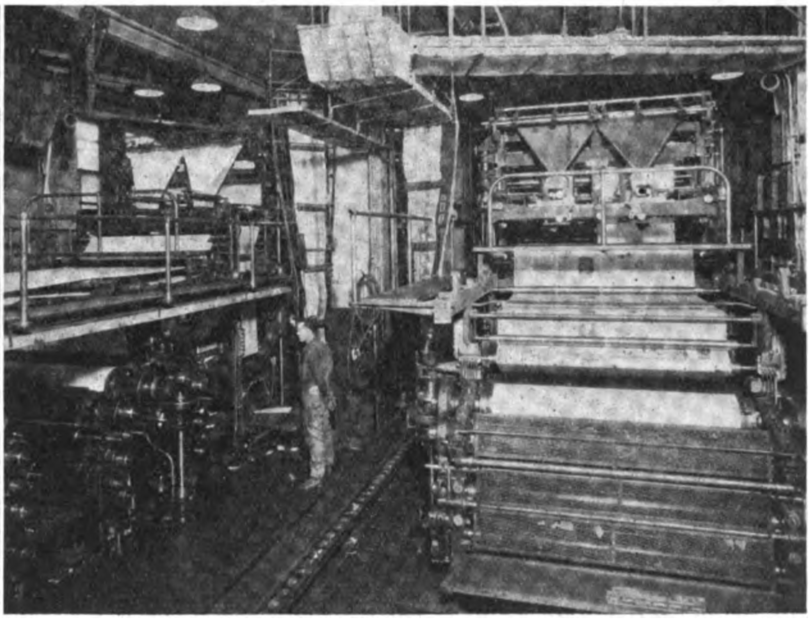
Since publication is entirely dependent upon a supply of paper, The Chicago Tribune Company some years ago purchased 500 sq. mi. of timber land far up on the Gulf of St. Lawrence. It also established a paper mill at Thorold, Ontario, not far from Niagara Falls. The pulp logs are cut in the winter, floated down to the Gulf in the spring and then shipped to the paper mill. Last year about 93,500 tons of paper were used by The Chicago Tribune alone.

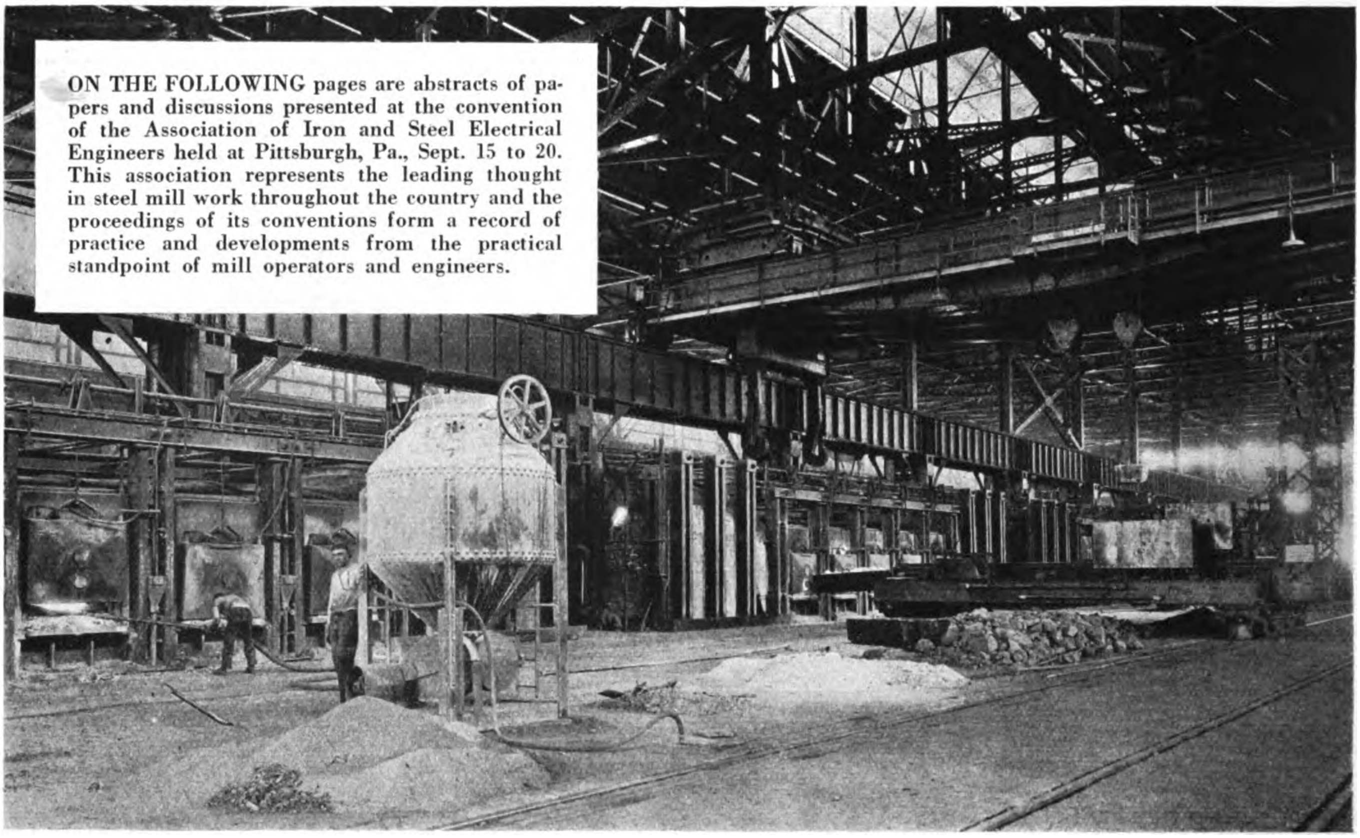
The problems of newspaper publishing are seldom realized by those not familiar with the industry. The fact that practically all news and advertising in the paper comes into the office, much of it by wire from all over the world, is rewritten, edited, set in type, stereotyped and printed all within a day and much of it in the late afternoon and evening, gives some idea of the work and the equipment involved. Since news a day old is no longer news, the equipment must be maintained in such shape that it will always function.

Two views in the press room of The Chicago Tribune plant.

Despite the intricate mechanism of these presses, practically the only interruptions are due to breakage of paper. This is largely due to the careful attention given to them every day while idle. When operating at full speed, each press will deliver 600 Tribunes per minute, or two complete newspapers for each revolution of the cylinder. The newspaper presses are 230 ft. long. Each unit, or the whole press may be controlled by push buttons placed within convenient reach of the pressman. The papers as finished are folded and carried on a special conveyor, shown just behind the man in the illustration below, across to the mailing room. The maximum press capacity is 1,130,000 40-page Tribunes daily.







Details of the

Topics Discussed by Steel Men

At the Convention of Association of Iron and Steel Electrical Engineers Held Last Month at Pittsburgh, Pa.

PRACTICALLY every important phase of steel mill operation had a place on the program of the annual convention of the Association of Iron & Steel Electrical Engineers held at Duquesne Garden, Pittsburgh, Pa., September 15 to 20. In the main, the papers were free from theoretical viewpoints and dealt with the practical phases of steel-mill problems that are now being faced or have been successfully worked out during the last two years.

Abstracts of the principal papers are presented in what follows. The main points brought out by different steel mill operators in their discussions of these papers are given in the reports beginning on page 474.

Maintenance Practice in Steel Mills

Discussion Conducted By

A. C. CUMMINS

Electrical Superintendent, Carnegie Steel Company, Duquesne, Pa.

THE following outline of the different maintenance operations usually carried on in steel mill shops, was forwarded to the members of the Association with the request that they go over this matter carefully and come to the convention prepared to take part in the discussion of the subjects outlined.

(1) General Motor Repair Shop Practice.

(a) Shop cleaning of equipment received for repairs. Best and most economical method.

(b) Inspection and test of equipment returned for repair; procedure and practice.

(c) Do you advocate running test of repaired equipment as final test?

(d) Has the apprentice system of training shop personnel proved satisfactory?

(2) Armature Repair Practice, D. C. Equipment:

(a) Should all armatures arriving at shop with one or more damaged coils be rewound, or should damaged coils be replaced without complete rewind? Have you any definite data on this subject?

(b) Should damaged commutators be repaired at mill shops, or is it more economical to return damaged commutators to manufacturer for repair? What shop equipment is necessary for a good commutator job?

(c) What increased service has been obtained by the adoption of the dipping and baking process in treating armatures to give better insulating qualities? Have you any objections to the use of this process? Definite figures on this subject are very desirable.

(d) Have you adopted anything new to prevent breaking of armature leads in wire wound coils? What is best practice in reinforcing broken leads on

armatures which give trouble in this respect?

(e) What is best practice in reference to shafts in regard to the following:

1. Bent shafts.
2. Worn journals.
3. Worn pinion fits.
4. Bad keyways.

(f) Commutators:

1. Do factory commutators prove sufficiently superior to justify the additional cost?

2. Do you advocate purchasing assembled bars or complete commutators mounted on bushings?

3. Do you know of any oil-proof paint or cement which will delay damage to commutator insulations caused by oil or grease?

4. Have you any application where undercutting does not seem practicable?

5. Do high-grade brushes bring any tangible returns in increased commutator life?

(g) What is best practice regarding bearings in the following details:

1. What is permissible radial wear in d. c. armatures?

2. What is permissible radial wear in induction motors?

3. Have you found any quick way, that is dependable, to inspect bearings for radial wear?

4. In rebabbitting shells is it always necessary to first tin shells as recommended by manufacturers?

5. Do you use any special care in handling babbitt? If a change in babbitting has recently been made have you noted any superior service? Does pyrometer equipment actually enable babbitt men to do enough better work to justify the investment?

6. Do modern babbitt bearing designs eliminate oil from armatures? What does shop observe?

(h) What is best practice with antifriction bearings in regard to the following:

1. Removal from shafts without damage?

2. What is their ultimate life? How should greasing be handled?

3. Do motors equipped with antifriction bearings reach shop absolutely free of grease and oil on windings and commutators? More or less than latest babbitt bearing types?

(i) Coils.

1. Do you advocate electric shops equipping themselves to make their own coils? Let us hear your views on this subject.

(j) Assuming you are using a dipping and baking process of varnishing armatures what is the best practice in handling the following details:

1. Cleaning after winding, but before drying.

2. Drying, before dipping.

3. Dipping, how immersed, and for how long?

4. Do you know of any special varnish characteristics which have proved specially desirable?

5. How should excess varnish be removed? Why should it be removed?

6. What are the most satisfactory baking temperatures and baking times?

(3) A. C. STATOR PRACTICE—CORES.

(a) When is restacking necessary? How may it be avoided?

(b) Best practice in preparing cores for winding?

(c) Are riveted laminations proving superior to older designs?

WINDING PRACTICE.

(a) Insulation of slots.
(b) Coil insulation.
(c) Dipping and baking.
(d) Kinks.

ROTORS.

(a) Is welding squirrel-cage end rings to bars of old motors desirable?

(b) If so, are bars installed in slots bare, or is it best practice to use insulation as originally designed?

(c) In what way does shop practice in handling wound rotors differ from d. c. practice?

(d) Are there any reasons why dipping and baking are not desirable in wound rotors?

(4) CONTROLLERS.

(a) Should control be repaired by shop men or general mill maintenance men? Why? What is the extent of repair?

(b) If control is repaired in shop what provision is necessary for test and adjustment before storing as spare equipment?

(c) Should resistance be standardized? What steps have you taken to reduce the number of different grid sizes required?

(d) Have you any special "stunts" for handling control repairs?

(5) FINAL.

(a) How are shops to keep down investment in supplies? Some works have 50 per cent of their total electrical stores invested in armature coils. How can this be kept down?

(b) What proportion of running armatures should be stored as spares?

* * * *

Discussion on Maintenance Practice

The discussion of the questions presented by Chairman A. C. Cummins, centered around the problem of whether renewal and repair parts should be made in the steel plant repair shop or purchased from the motor or control manufacturer. Opinions differed, but the majority took the stand that renewal parts for modern equipment should be purchased, while the parts for the older and more or less obsolete apparatus could be handled to better advantage in the plant repair shop.

Mr. Cummins spoke of the necessity of determining accurate shop costs and the value of analyzing them. He has found the charges against motors of 40 hp. to 60 hp. in plants having 40,000 to 60,000 hp. of motors will range from $60 to $100 per year per motor. These charges include material, labor and overhead, such as executives' and foremen's salaries, storeroom costs and the like. Every means available should be used to reduce this overhead. One way to save is by careful collection and disposal of waste brass, copper and the like. This should be collected and credited to the electric shop.

A. J. Standing of the Saucon plant of the Bethlehem Steel Co. stated that a repair shop should confine itself to maintenance and repair and not attempt the manufacture of repair parts. Building new equipment or parts runs up the overhead charges because better and more skillful men are required for such work, to say nothing of the development work required in making the parts. The motor or control manufacturer can pay good prices for men to do this kind of work and absorb these costs in large production. He further stated that the plant electric shop should go as far into repair as possible, but should avoid the extensive making of coils, commutators and the like. W. T. Snyder of the National Tube Co., McKeesport, Pa., also stated that the manufacture of repair parts is outside the province of the repair shop.

G. E. Stolz said that the equipment manufacturer cannot answer the question as to what parts can best be made in the repair shop. It is a question of accounting. The shopman should obtain accurate data on the cost of making repair parts in his own plant and then carefully consider the life of the parts of his own manufacture as compared with the life of the manufacturer's parts. It comes back to a question of cost per year rather than cost per coil or per part.

On the other hand, F. W. Cramer of the Cambria Plant of the Bethlehem Steel Co. stated that a great deal of parts manufacture, particularly coil winding, is done at his plant. This works out advantageously when the plant is not located close to a large manufacturer and trouble is had in obtaining quick shipment of the necessary parts. He also said that the manufacturer's price of coils for old or obsolete motors is high. Consequently, all of this material is made at the plant. If such coils were bought and stored several years they would deteriorate so as to be worthless; hence the value of making them shortly before being used. At this plant an accurate record is kept of the cost of making coils; consequently they are in a position to know what coils they can profitably make. He stated that he was not able to show a saving in making coils for modern motors.

J. A. Morgan of the Edgar Thomson Works of the Carnegie Steel Co. stated that they manufacture coils in sizes up to 50 hp. They dip and

bake the coils but do not impregnate them.

Mr. Morgan advocated complete rewinding of damaged armatures unless the defects are very slight. Mr. Blakeslee stated that most armatures have to be completely rewound and that unless the coils are soft and flexible, most of the coils from a damaged armature have to be replaced.

Mr. Snyder said that some shops are not keeping step with other developments in the mill. Mr. Cummins advocated the use of commercial repair shops by small plants that are convenient to them.

In cleaning motors and equipment before being repaired, Mr. Standing stated that the equipment was blown out with compressed air. This was done outdoors and not in the shop. Other operators stressed the same point. The value of dipping and baking armatures after rewinding was acknowledged by several speakers.

Opinion was divided on the advisability of straightening bent shafts. Mr. Standing stated that he discarded bent shafts. John C. Reed of the Steelton (Pa.) plant of the Bethlehem Steel Co. and J. A. Morgan said that they straightened the smaller shafts after they had been bent. D. W. Blakeslee of the Jones & Laughlin Steel Corp. said the same practice was followed at his plant. All the men discussing the paper spoke of the successful use of arc welding for building up worn pinion fits, worn journals and damaged keyways. Mr. Morgan reported success in welding broken armature shafts.

Mr. Reed advocated a running test of repaired equipment — no-load tests, ground and high-potential tests being recommended.

Mr. Cramer spoke of the necessity for protection of armatures during the time they leave the motors until they reach the repair shop and likewise on their return trip. Since it is impossible to handle the armatures carefully in the steel plant they have made round steel cases which will hold the armature complete with its bearings. The armature is placed in this case and thus protected during transit to and from the repair shop.

He also mentioned that they do not change armature bearings in the field. All armatures are fitted with bearings in the shop and when an armature is changed the bearings are also changed.

Opinion was divided on the problem of commutator repair. Mr. Reed repairs a great many commutators. Mr. Blakeslee stated that it was more economical to repair commutators than to send them out. On the other hand, Mr. Morgan does very little commutator repair work and finds it advisable to have such work done in commercial repair shops.

Mr. Reed stated that he kept all of his commutators undercut, while Mr. Blakeslee felt that a damp location was undesirable for an undercut commutator. Mr. Reed also emphasized the economy resulting from the use of high-grade brushes.

In commenting on bearings he said that about $\frac{1}{32}$-in. radial play is permitted before discarding them. This play is determined by prying up the pinion with a bar and also by checking with feelers under the pole pieces. Mr. Blakeslee stated that the amount of play cannot be fixed—that it depends upon the size of the motor.

Mr. Reed does not believe in making his own babbitt metal. Most operators discussing the question use the "stick" method of determining babbitt temperature and seem to find it satisfactory.

Mr. Blakeslee said that he left most of the control repairs to the general maintenance men.

The advisability of piece-work methods in the repair shop received some discussion. A few operators are trying to standardize shop methods and put in piece-work practice.

Mr. Standing stated that 21 per cent of his armatures are spares and that he believed this amount was too high. He and Mr. Blakeslee both said that the amount of spares depends upon the condition of the mill and the character of the drive. A motor which, if it should fail, would tie up a whole mill or a vital section of it, naturally should have complete spare-part protection. With less important motors less protection is required.

Rolling Mill Adjustable-Speed Drives

By L. A. UMANSKY

Industrial Engineering Department, General Electric Company, Schenectady, New York

THERE ARE a good many reasons why most of the mills with a diversified line of products should have several rolling speeds. A uniform average speed may be a poor compromise: the output of lighter sections may be curtailed; they will be rolled at a lower temperature and the amount of power per ton of steel rolled will be appreciably higher; some small sections would be so cold in the finishing passes that the quality of the product would be impaired. Likewise, troubles may be expected with heavier sections; the compromise speed may be too high for the rolls to get a good hold on the metal when the steel enters the mill. It might happen that, by selecting a constant-speed drive for such mill, the extreme light and heavy sections could not be rolled on it at all and the work would have to be passed to other mills, if such are available.

It should be stated at the very beginning, that any electrical adjustable-speed drive, regardless of the speed-regulating system employed, costs appreciably more than a constant-speed drive. However, the primary purpose of any mill is to roll steel—the more of it the better. There is no use comparing costs of several systems of electric drive without checking their effect on the mill output; the most economical drive is not the one that has the lowest cost, but the one that costs the least per ton of steel rolled. The cost of electrical equipment is only a part of the cost of the whole; one is truly wise who pays more for a part to save on the whole. In selecting a system for driving a mill the drive should be fitted to the mill and not the mill to a type of drive favored for reasons other than mill requirements.

[The body of the paper is devoted to a discussion of the mode of operation, characteristics, advantages and disadvantages, and the factors governing the selection of the following types of drive: two-speed drive; wound-rotor induction motor with secondary resistance; Scherbius system; Kraemer system; frequency converter system; brush-shifting, alternating-current motors; direct-current motors using field control; direct-current motors using voltage control; direct-current motors using a combination of field control and voltage control; and direct-current motors using a combination of field control and voltage control. Due to the length of this discussion it cannot be abstracted in the space available.]

While it is extremely difficult to set hard and fast rules for making the choice between the various systems of adjustable-speed drive, the

following conclusions, are believed to be generally true;

(1) An alternating-current drive has a better efficiency than a direct-current drive. The larger the mill tonnage is, the more valuable becomes each per cent gain in efficiency.

(2) Alternating-current, adjustable-speed drives are capable of correcting their power factor and bringing it close to unity. Direct-current drive with synchronous motor generators have leading power factors on the alternating-current line, and are capable of providing leading corrective kilovolt-amperes.

(3) When isolated mill drives are considered, the alternating-current drive will, in most cases, be found lower in the first cost than in the maintenance. The reliability is greater.

(4) With several drives driving the same mill, the direct-current proposition may have a lower first cost. Only a close analysis will show where the dividing line is.

(5) The increase of speed regulating range is more expensive with alternating-current drive than with direct current. A speed range of substantially more than 2 to 1 may be too expensive for alternating current.

(6) The larger the capacity of the drive is, all other things being equal, the more prominent become the advantages of the alternating-current drive. For very small capacities, like 300 to 400 hp., the cost per horsepower of the regulating equipment for an alternating-current motor becomes high.

If a choice is to be made between a Scherbius or Kraemer system the following factors should be noted:

(1) The Scherbius system can give a double-range operation; the main motor can run non-regulating and roll the majority of sections at the average speed.

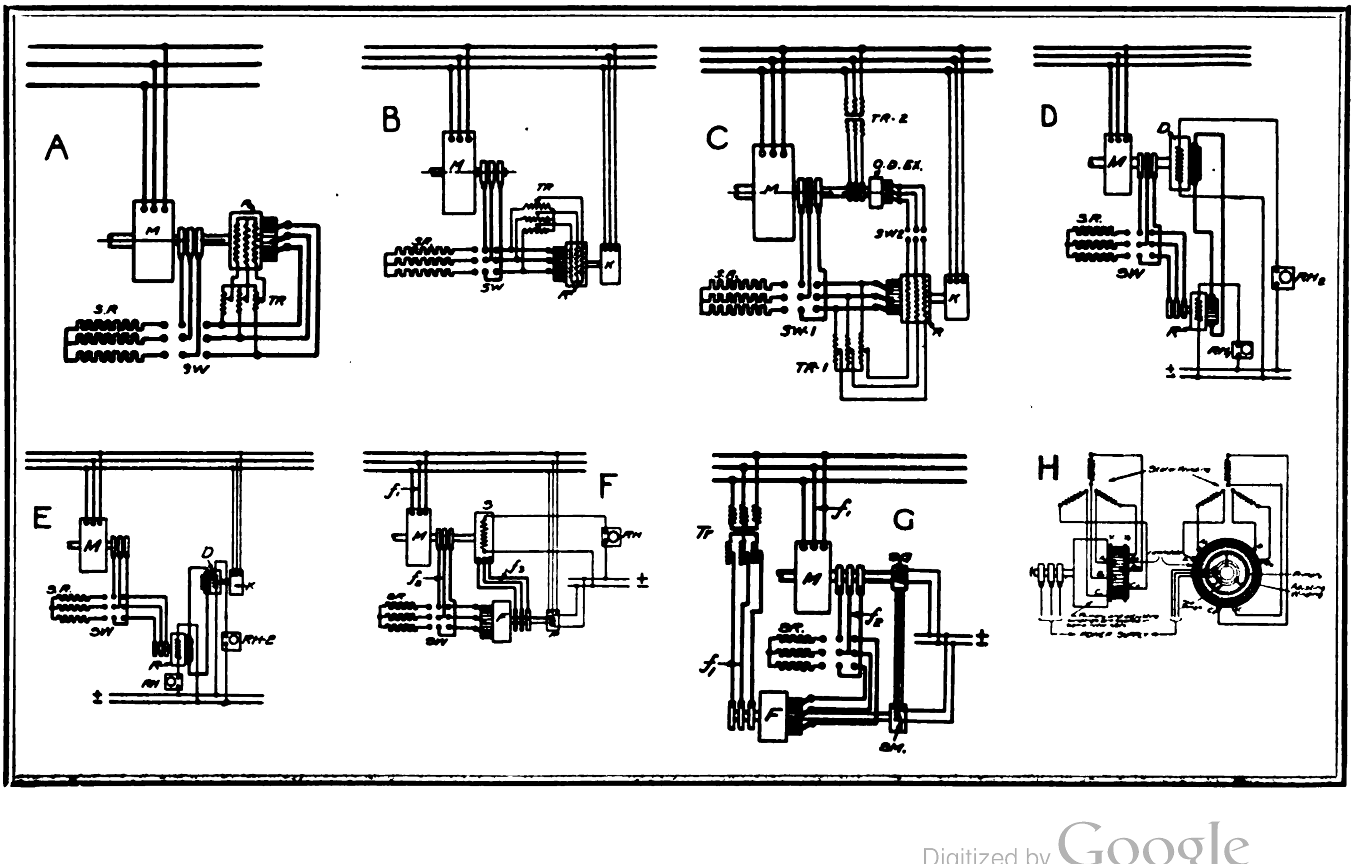
(2) The efficiency and power factors of both systems are about the same.

(3) Either Scherbius or Kraemer can be built for constant horsepower or constant torque. On the same basis, the Scherbius system employs one less machine than the Kraemer system.

(4) The control of the Scherbius drive is somewhat more complicated. The control, however, consists of standard devices and is just as reliable as that of any constant-speed induction motor.

(5) The use of 60-cycle power as compared with 25-cycle lowers the cost of the Kraemer drive, but does not increase the cost of the Scherbius equipment. The speed regulation of the 60-cycle, double-range, Scherbius drive is limited to approximately 30 per cent above and below synchronism, that is, to a maximum speed range of 130 to 70 = 1.85 to 1.

Nowhere as in the question of adjustable-speed drive should engineering analysis be given a freer hand. It is far better to make a complete preliminary study of the subject, than to make a rash and possibly wrong decision and then pay for it in tons that might have been rolled.



Diagrams of the principal connections for eight forms of adjustable-speed drives.

In diagram A is shown the principal connections of a single-range Scherbius drive of the constant-horsepower type. *M* is the main induction motor, on the shaft of which is placed the regulating machine *R*. *Tr* is the field control transformer used for speed adjustment. *Sw* is the throwover switch to throw from the starting resistors *SR* to the regulating machine *R*. At B is shown the connections for a similar set of the constant-torque type. In this set the regulating machine *R* is not connected to the shaft of the main motor *M*, but is connected to the shaft of a squirrel-cage, induction motor *K*. At C the addition of the ohmic-drop exciter *ODEx* permits speed regulation not only below but also at and above synchronous speed of the main motor. This layout is known as a double-range, Scherbius drive. *TR-2* is the stepdown transformer for the ohmic-drop exciter. At D is shown an elementary diagram of connections for a constant-horsepower Kraemer drive. *M* is the main induction motor on the same shaft of which is a direct-current motor *D*. *R* is a rotary converter and RH_1 and RH_2 are field rheostats. *D* Diagram E is for a constant-torque. Kraemer drive. This set differs in that the motor *D* is taken from the shaft of the main motor *M* and connected to an induction motor *K*. Diagram F is for a constant-horsepower, frequency-converter drive. *M* is the main induction motor, *F* is the frequency changer, *S* is a synchronous motor and *P* is a small synchronous motor for driving the frequency changer at synchronous speed. Diagram G is for a constant-torque, frequency-converter drive. In this diagram *M* is the main induction motor, *F* is the frequency changer. *SG* is a small synchronous generator, *SM* is a small synchronous motor, *TR* is a transformer for transmitting the slip energy between the line and the frequency changer, and is used for speed adjustment. H is the elementary diagram of connections for a brush-shifting, polyphase, adjustable-speed motor.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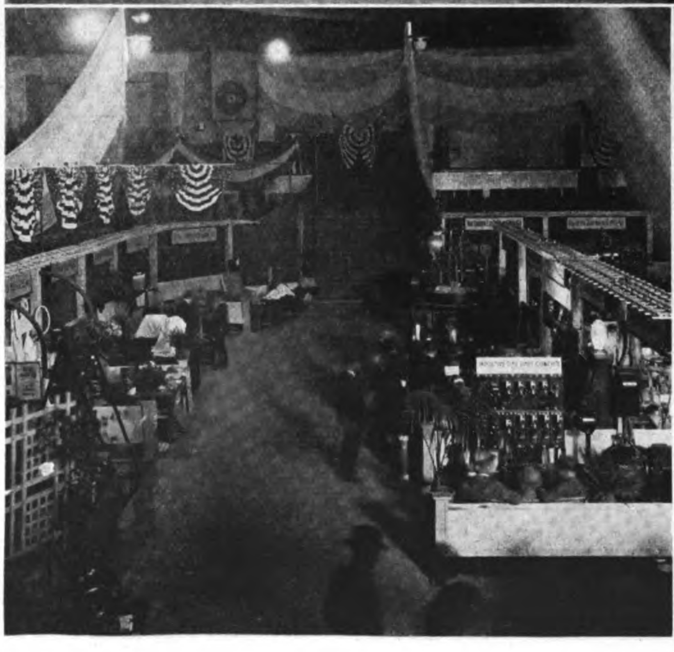


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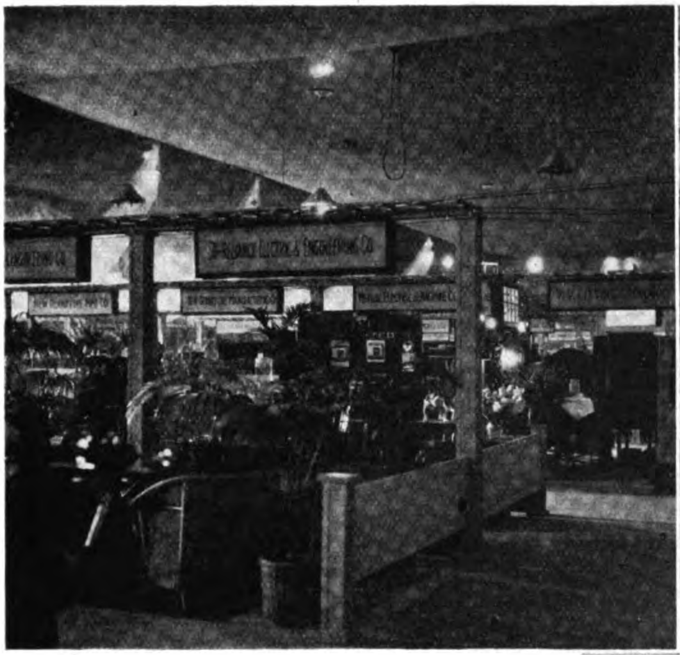


Steel Mill Equipment Show

At Pittsburgh Convention of Association of Iron and Steel Electrical Engineers

The million-dollar exposition of equipment for steel mills is shown from several different angles in the pictures on these two pages. More than one hundred companies displayed the latest developments in a wide variety of equipment used in the iron and steel industry.

Crane Hoist Travel Limit Devices

By WALTER GREENWOOD
Safety Engineer, Ohio Works, Carnegie Steel Co., Youngstown, Ohio.

FAILURE of regulating devices for control of electrical apparatus is the chief cause of mishaps that cause impairment of electrical equipment, and machinery operated by electrical equipment. Also, it is the cause for delay of operations, loss of production and injuries to persons while engaged in handling electrically-operated equipment. The list of devices that fail and produce disastrous results include automatic breakers of various kinds, switches, speed limits and travel limits.

The failure of hoist-limit devices is of such frequent occurrence that we are not surprised at the attitude of some whose preference is to rely entirely on operators to stop the hoist travel at the proper time instead of employing a limit device that is not entirely dependable.

It is a general belief that limit devices where installed, have very nearly made impossible mishaps that can occur from neglect of operators to apply the control equipment. It is known that limit devices, claimed by their makers to be faultless and infallible, do fail. In answer to the question, "Are they entirely dependable?" the common reply is "No." Replies made by some superintendents, where a large number of cranes are included under their management, is that failure of some one of the total number of limits employed does occur as often as once each week. These failures frequently are expensive; sometimes the expense is increased by delay of operation and loss of production. Loss of life from such mishaps is not an uncommon occurrence.

In discussing hoist limits with various persons, these points have been agreed upon: a hoist-limit device should be considered as only an auxiliary to manual control. The principle features of limits are interruption of current and the application of dynamic breaking; the addition of any other feature involves care and attention that means additional maintenance cost. If they do not automatically reset, the time consumed in resetting, if the method is purposely made inconvenient, will sometimes be a serious delay. This encourages operators to make the limit inoperative. If proper attention is not given to the method of installation and to maintenance their reliability is much affected.

In too many cases, the installation of a protective device is made by persons who in some particulars disregard instructions furnished by the maker of the device. This is done in some cases because the requirements are thought to be unnecessary and cost can be reduced; in other cases because they think they can see better methods.

Power in the Iron and Steel Industry

By BARTON R. SHOVER
Consulting Engineer, Pittsburgh, Pa.

SECOND only in importance to the supply of raw materials for making iron and steel is power, whether human or mechanical, and the tendency of man to shirk physical labor together with the growing demand for the product and the increasing cost of fuel, make the problem of mechanical power one of vital interest.

From data taken from the Statistical Report of the American Iron & Steel Institute and from findings of the Carnegie Institute, it is estimated that the steel industry consumes for power purposes only, more than 12,400,000 tons of coal per year for the average production and over 15,900,000 tons for maximum production; should all plants operate to capacity, nearly 21,400,000 tons would be required. In this connection a table was presented showing the number of power units and their rated horsepower for the plants consuming this coal.

From data collected by the Association of Iron & Steel Electrical Engineers for 1923, the ratio of the horsepower of prime movers driving electric generators to the horsepower of motors installed is 0.59 to 1. A study of data submitted by different companies developed the fact that the more completely the plant is electrified, the higher is the ratio between generator and motor capacity; in other words, the better is the load factor of the motor installation. Some of the older plants where motors were used for cranes, tables, etc., only, had a ratio that was as low as 1 to 7.

Practically all primary power generated in the steel plant comes either from steam or internal-combustion engines. While reciprocating engines still comprise the larger proportion of power units, the turbine is coming more and more into use. Although a great number of internal-combustion engines have been used, conditions have changed such that there is now a strong tendency in the other direction. Increase in speed, capacity and efficiency of the turbine, together with its lessening cost per horsepower, has swung the tendency towards it. Close inquiry shows the installation of only five gas-engine, generating units aggregating 21,140 kw. capacity, since 1918. This capacity compares with the 357,375 kw. of turbo-generators which have been installed during the same period and clearly shows which method of power generation is at present preferred.

Data from the last annual report of the Bureau of Census shows that while the increase in the total capacity of motors operated from plant power was 1,113,576 hp., or 140 per cent, the increase in capacity of motors operated from purchased power was 727,475 hp., or 949 per cent. The increase in capacity of motors operated from purchased power being so nearly equal to that of motors operated from plant power shows that purchased power must be considered as part of the power system and that there is an increasing tendency to depend more and more on electric power generated outside the works, principally by public-service companies.

Although a large quantity of coal is consumed, a large amount of by-product fuel and waste heat are used for power generation. It can be shown that there is more than sufficient waste heat available for power requirements in plants having coke ovens and blast furnaces. On an average twice as much waste heat as should be required, is used for power purposes, to say nothing of half

again as much coal in addition, or a total of five times the calculated requirements. This offers a fertile field for the development of future economy.

Coke ovens and blast furnaces operate continuously, whereas steel works and rolling mills are normally idle over the week end; consequently, about one-seventh of the waste heat from the principal sources is given off when there is no use for it by its largest consumers. This condition can be met by interchanging electric power with the local public-service company. There are at least three places where this arrangement is in force and two others where negotiations toward this end are now in progress.

Power is applied directly or through electric energy, compressed air, or hydraulic pressure, but the amount used by the last two is so small a percentage of the total that it can be neglected. Because of its lack of overload capacity and inability to adapt itself to sudden changes in load, the internal-combustion engine is not suitable for driving roll trains or other apparatus of this character, but is well adapted for driving reciprocating, blast-furnace blowers. Due to lower first cost and convenience of operation, the turbo-blower has of late years made considerable headway. While it can show advantages in every respect over the reciprocating steam engine for blowing blast furnaces, the gas engine excels it in thermal efficiency. In fact, there is still a question, in spite of the higher first cost and operating expense, as to which of the two types of blowing units will show the better returns on the investment required.

In 1914, a turbine was direct connected to a roll train and although this outfit is still operating, it has never been duplicated; consequently, it can be assumed that the results of such drive are not satisfactory.

It is not within the scope of this paper to argue the merits of the different kinds of power units for main roll drive, but the tendency toward the use of electric motors as opposed to steam engines is too marked to allow passing without notice. Common practice is a good argument. In 1923, one electrical manufacturing company furnished nine motors aggregating 27,650 hp., to replace existing steam engines driving roll trains. Two other electrical companies report having furnished a total of forty-seven motors aggregating 103,565 hp. for this purpose. Against this showing not a single motor driving roll trains has been replaced by any other kind of power.

From the data, estimates and general history of the art as outlined above, the following is deduced as the present and probable future tendency of power generation and application in the iron and steel industry:

(1) The electrification of all power-driven apparatus except blast-furnace blowers.

(2) Substitution of turbo-blowers, or possibly gas engines for reciprocating-type, steam blowing engines.

(3) Purchase of power requirements by plants which have no waste heat available.

(4) Complete economical utilization of waste heat by means of turbo-generators for electric-power generation, except where this heat can be used to better advantage for "process" or has a market value greater than its coal equivalent.

(5) Interchange of electric power between plants of public-service companies and plants generating power from waste heat.

Report of Electric Furnace Committee

By GEORGE H. SCHAEFFER, Chairman
Electrical Engineer, Carpenter Steel Company, Reading, Pa.

THE question as to the effect on the steel of nitrogen generated by the electric arc of the furnace while melting down at a high voltage has been an open one. In the crucible, open hearth, Bessemer or electric furnace process, there is ever present the nitrogen content in the atmosphere, and an equal opportunity for chemical combination. From all available information we feel confident that within the limits of melting now used commercially, for example up to 210 volts, the electric arc does not cause a chemical combination of nitrogen with the steel bath. We are supported in this contention by the following information furnished by the Bureau of Standards:

"Electric steels normally contain from 0.002 to 0.005 per cent nitrogen. Open hearth steels contain nitrogen in about the same range—while the Bessemer steels normally carry from 0.010 to 0.015 per cent of nitrogen."

Serious consideration is now being given to high frequency induction furnaces on a comparatively large scale for the production of high-grade alloys for special purposes and for refining precious metals, although there have been no commercial installations.

Inasmuch as the previous reports dealt mostly with electric melting, the board of directors asked that we devote most of our time to the medium- and low-temperature equipment. With this idea in view, we have limited the subject of electric melting furnaces to detailing the improvements to furnaces, furnace control and furnace operation that have taken place since the last electric furnace report.

Electric Melting Furnaces

By J. A. SEEDE
Electrical Engineer, General Electric Co., Schenectady, N. Y.

THAT any change in electric furnace practice is worth consideration is indicated by the 1923 electric furnace production of steel castings totaling 235,958 tons, or 50 per cent more than the best previous year, 1920, and the electric furnace production of alloy steel castings amounting to 29,054 tons or 64 per cent higher than the best previous year, 1922.

The most recent change has been in using so-called electrode economizers and the Soderberg electrode.

The electrode economizer is a device that fits closely about the electrode where it emerges from the roof, keeping the air from it and cooling it without oxidation.

The Soderberg or self-baking electrode will, undoubtedly, continue to be a source of discussion for some time to come. These electrodes have become firmly established in smelting furnaces, and are being successfully used in steel melting furnaces.

The productive capacity of a furnace unit may be increased by short-

ening the time to produce a heat and decreasing the time between heats. Electric heating is used to best advantage when preliminary heating has been done with cheaper sources of heat, but it is doubtful if all the possible advantages have been realized. Preheating by oil or gas in the Loshbough combined charging bucket and preheater, in combination with an opening roof furnace is interesting. That such a method is profitable is indicated by the energy consumption dropping in several installations from approximately 600-kw.-hr. per ton to less than 400 kw.-hr.

The need for increased production has led to a gradual increase in input to arc furnaces from 225 kva. for a 1-ton furnace to 600 kva and higher at the present time.

With the original equipment, it was a simple matter to obtain fair operation with one secondary voltage, about 60 volts across the arc, but with increased capacities, a higher voltage for melting and lower voltage for refining seem to offer advantages over methods previously used.

Reducing time between heats is a mechanical problem which involves getting the melted metal into ladles and charging the furnace with the minimum possible delay. Three solutions have been offered for this problem: charging machines, opening roof furnace and multiple melting furnace. The latter involves the use of one set of electrodes, transformers and control panels with two furnace shells mounted on a turn table. This makes a very compact arrangement, and in place of the 20 to 30-min. intervals between heats, 4-min. intervals are common.

Brief reference to the largest induction furnace now operating in this country may be of value. For several years a 2-ton furnace has been operating at the Pittsfield works of the General Electric Co., with entire success. The linings now average 500 heats and individual linings occasionally go 30 per cent above this figure.

Low-Temperature Applications

By E. A. HURME
Manager, Steel Mill Section, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

THE field of industrial heating can be divided into two classes: medium- and low-temperature applications. Medium-temperature units are ordinarily classed as furnaces and operate from 1,000 deg. F. to 2,000 deg. F. Low-temperature units are classed as ovens and operate at temperatures below 1,000 deg. F.

One of the most successful applications of hearth-type industrial furnaces is in treating tool steel. Dies used in forming small parts by the die-casting process are subject to very high stresses and require special heat treatment.

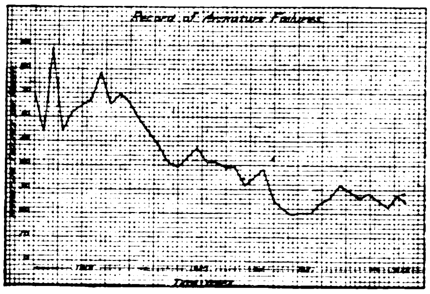
For this exacting work the Sanitary Tube & Stopper Company have adopted the electric furnace and find that they get better tops, save effort in heat treating dies and actually save $100.00 on each set hardened.

With the electrical equipment they are getting about one and one-half million tops from each set of dies. With the best gas-fired equipment, they could not expect to get half as many pieces and of the tops produced there would be many more poor ones.

Large industrial electric furnaces are used for a wide variety of purposes, the most important in iron and steel plants being the annealing of large castings, the annealing of sheets for stamping, hardening and tempering wire and steel springs, and hardening of steel parts.

A car-type annealing furnace 4 ft. wide, 6 ft. high and 10 ft. long is installed in the plant of the Keokuk Steel Castings Co. The heating elements in the walls and roof are covered with baffle plates.

The Transcona shops of the Canadian National Railways installed in 1923 a car-bottom-type electric furnace for annealing side rods, driving gear and coupler pockets of locomotives and cars.



Armature failures decreased by dipping and baking rewound armatures.

The curve shows how the armature failures decreased on an electric-railway installation after the dipping and baking of rewound armatures was adopted in 1919.

The average charge treated is 5 tons and the average weight of the pieces is over 150 lb. The production of the furnace is 8.34 lb. per kw.-hr. Including the cost of handling, the total cost is approximately $3.00 per ton.

The French Manufacturing Co., Waterbury, Conn., recently replaced a wood-fired, muffle-type annealing furnace with a 330-kw. electric furnace for annealing seamless brass tubing.

The power consumption averages 110 kw.-hr. per ton of brass annealed, or a production of 18.2 lb. of brass per kw.-hr. The cost of electric power exceeds the previous cost of fuel by only 7½ per cent, but other savings bring the cost of operation below that of the old fuel-fired furnaces.

Continuous electric furnaces are used by the Stewart Hartshorn Co., for annealing and hardening steel wire used for making small springs. The cost of operation shows a saving of over 32 cents per 100 lb. in favor of the electric furnace, as compared with the gas-heated furnace.

Heating units operating at temperatures below 1,000 deg. F., are classed as ovens. This class of heating element is used to advantage in iron and steel plants in such processes as the following: Drawing the temper of tool steel hardened in a medium-temperature furnace; baking sand cores; baking motor armatures, enameling. Under special applications are the following: Electric steam boilers, sheet mill roll heaters, heating of metal pattern plates, air heaters.

In the electric railway field the baking of rewound motor armatures has resulted in a materially increased life of the armatures in service. An increase of 75 per cent in the average life is not uncommon. The accompanying curve shows how the armature failures decreased on a typical electric railway installation after the dipping and baking of rewound armatures was adopted in 1919.

The similarity of mill- and crane-type motors to railway motors and the service to which they are subjected would indicate that the adoption of the practice in steel mill repair shops would be amply justified. A furnace capable of handling eight armatures per bake can be installed at an approximate cost of $1,200 to $1,400. Baking the armatures seals up the insulation which may have

been cracked during winding, excludes the moisture and prevents deterioration of the insulation. Few steel plants have tried the baking of rewound armatures.

The low-temperature oven has proven the ideal method for baking enamel on steel parts such as automobile fenders and batteries. With the electric oven a better finish is obtained, due to the more uniform application of the heat and there is less danger of explosion.

Electric preheating of the finishing rolls of sheet and tin mills is a new development in low-temperature electric heating. The marked benefits afforded and a pronounced superiority over any previous heating methods are rapidly establishing this as a distinct improvement in the art of rolling sheets.

Medium-Temperature Installations

By C. F. CONE
Engineer, George J. Hagen Company, Pittsburgh, Pa.

THE Fowler and Union Horse Nail Company, Buffalo, N. Y., decided to erect a new plant in Buffalo and felt that the installation of an electric furnace for the annealing of wire would eliminate many of their troubles in the manufacture of horseshoe nails.

The furnace purchased is known as the regenerative, car-type furnace. There are three chambers: heating, cooling and preheating. The cooling chamber is in tandem with the heating chamber with a common door between. The preheating chamber is at the side of the cooling chamber with the common wall removed to allow free interchange of heat from the hot to the cold charge.

The charge is 3/8-in. diameter wire in coils weighing approximately 250 lb. per coil. The coils are stacked and the charge per car is approximately 7,500 lb. The furnace delivers 3½ tons every three hours. The heating chamber temperature is held at 1360 deg. F. The total connected load is 180 kw. at 440 volts, three phase, 25 cycles.

The temperature of the heating chamber is automatically controlled by a potentiometer type of recording controller.

This furnace has been operating practically every working day since November, 1920, and has turned out several thousand tons of annealed wire without a single rejection or reheating.

Gray & Davis, Inc., Amesbury, Mass., do deep drawing of ¼-in. and 5/16-in stock. They draw in four operations and require two anneals. A pusher-type oil furnace was formerly used. Rejections were large, pickling costs were high and die life was short, due to excessive scale.

A counter-flow, regenerative car-type electric furnace was installed. It has six chambers, with two rows of cars moving in opposite directions. At each end is a preheating and cooling chamber with the common wall removed, thus permitting the transfer of heat from the hot to the cold charge.

The heating elements consist of heavy nickel-chromium ribbon suspended from the side walls on special hangers. Each heating chamber has a connected load of 110 kw. for operation on 220 volts, three phase, 60 cycles.

The furnace operates at 1,450 deg. F. and will handle 2,500 lb. per hour. On a 24-hr. cycle, the economy is 145 kw.-hr. per ton annealed.

The Canadian Allis-Chalmers Company, Toronto, Canada, desired a furnace to anneal transformer laminations, and felt that the electric furnace would give a lower unit cost than a fuel-fired furnace.

The furnace purchased was the double-end car type. The total connected load is 210 kw. for operation on 440 volts, three phase, 25 cycles. The average charge is 6,213 tons. Power is put on at 6 p. m. and the charge soaked all night at 1,600 deg. F. In the morning the hot car is removed and a cold car put into the furnace. The economy is 340 kw.-hr. per net ton annealed.

One of the most difficult problems of the Nash Motor Co., is the heat treating of automobile parts. This operation was formerly carried on unsatisfactorily in box-type, fuel-fired furnaces.

The parts to be heated vary from a small spring clip to a large front axle. The rotary-type furnace was finally selected. The rotating table revolves on rollers. The total connected load is 323 kw. for operation on 440 volts, three phase, 60 cycles. When operating on hardening, the furnace heats 3,000 lb. per hour and the economy is 170 kw.-hr. per ton at 1525 deg. F.

Another automobile company selected a rotary-type furnace for carburizing. The heating elements consist of heavy nickel-chromium ribbon suspended from the side walls. The chamber is divided into five zones, although there are only three control instruments. Three temperature zones are established which may be controlled independently of each other. Two furnaces were installed and each has a total connected load of 500 kw. for operation on 220 volts, three phase, 60 cycles.

The time cycle in the electric furnace is 12 hr., compared to 15 hr. in the oil-fired furnace. The economy is 200 kw.-hr. per gross ton. This actually gives a lower fuel cost than was obtained from twenty-five oil-fired furnaces in the same department. The saving in fuel and labor represents a return on the investment for the two electric furnaces of 81.7 per cent a year.

The Royal Typewriter Company had been having difficulty with the excessive wear on typewriter parts and finally selected a box-type electric furnace for treating these.

This furnace is 4 ft. 10 in. long, 3 ft. wide and 2 ft. high inside. The total connected load is 60 kw. at 220 volts, two phase, 60 cycles.

The operating temperature is 1,650 deg. F. and the average gross charge is 1,100 lb. The heating time is 5 hr. and the economy is 360 kw.-hr. per gross ton.

More box-type electric furnaces have been installed than any other type. The sizes vary from the small laboratory furnace to the large size working on a tonnage basis. One box-type furnace operating in the heat-treating room of a large tube mill is used for hardening dies. Since this furnace has been in operation, it is evident that they will obtain an increased die life of 33 per cent at least.

The electric furnace has met with its greatest success in the vitreous enameling industry. The electric furnace atmosphere is slightly oxidizing, which is ideal for this kind of work. There are no fumes or dirt which will discolor the ware. The temperature distribution is even so that all parts receive the same burning.

A number of furnaces, consisting of a main or upper burning chamber with an auxiliary or lower burning chamber, have been installed.

Main Points in the Discussion at Pittsburgh Convention

ALL those taking part in the discussion of the paper on "Adjustable Speed Drives for Rolling Mills" agreed that L. A. Umansky had written a very practical and comprehensive paper that added much to existing engineering literature on the subject. F. R. Burt pointed out that reliability must not be sacrificed for over-all efficiency when making a drive selection. He further stated that the speed of rolling is a matter of judgment and skill on the part of the operators, and as such cannot always be estimated as closely as might be thought. After an installation has been completed, operating conditions often change to such an extent that the original calculations do not hold true. F. B. Crosby said that it pays to spend money at the time of installation to make provision for rolling a variety of products, for after a mill has been installed it often is required to roll a product quite different from what was originally intended. He emphasized the necessity of considering all factors when making a drive selection for an adjustable-speed mill. In closing the discussion Mr. Umansky emphatically recommended that alternating-current drives should be used whenever possible and direct-current drives only when compelled to by special conditions, owing to the better over-all efficiency of the alternating-current drive.

Electric Melting Furnaces.—In the discussion of the papers on "Electric Furnace Installation" by Roy S. Sawdey, "Report of Electric Furnace Committee for 1924" by George H. Schaeffer, Chairman, and "Electric Melting Furnaces" by J. A. Seede, emphasis was placed on the reduction in melting time and increase in capacity obtained through the use of furnace improvements, including automatic control, Soderberg self-baking electrodes and other electrical equipment. Dr. Sem, who is visiting from Norway, discussed the operation and use of the Soderberg electrode. He said that the first self-baking electrode installation was made over five years ago and during that time some 850 ft. of electrode had been consumed without an electrode failure. In this connection he said that the installation has resulted in a 30 per cent saving in electrode cost as compared to the European carbon electrodes formerly used and a saving of 7½ per cent in power consumption, due to more regular furnace operation. He pointed out that one of the greatest advantages of this electrode is that it may be made in any shape or size, thus making the electrode fit the furnace and not cause the furnace to be designed for the electrode.

Some question was raised in regard to the load factors obtainable with multiple and single furnaces. One operator stated that he believed the load factors of 70 per cent for the former and 45 per cent for the single furnaces were too high.

Medium and Low Temperature Applications.—In discussing this paper by E. A. Hurme and "Medium Temperature Furnace Installation," by C. F. Cone, Gordon Fox of Freyn, Brassert & Co., stated that the first complete installation of electric roll heaters has just been finished. Heretofore mills have only put in a few heaters, but this installation at a large sheet mill in Ohio consists of one roll heater for each of the fourteen stands in the mill. A very convenient method of handling and storing the heaters in racks has been developed and is in use in this plant. He stated that through the use of these heaters it was possible to start rolling good quality sheets at the beginning of the first turn and that the tonnage on the first turn was comparable to that of the other turns, which is twice as much as obtained before.

The value of a demand-limiting device for use with furnaces was mentioned and described. It is attached to demand meters to give warning of or prevent an unusual and infrequent demand that would establish an excessive power rate. The author mentioned that the device makes it possible to control the peaks of furnace loads and save many times the installation cost in a single year.

A new elevated type of furnace having no door was also mentioned. It was stated that the use of this construction results in a furnace having a burned-out atmosphere with no scale forming or oxidizing action.

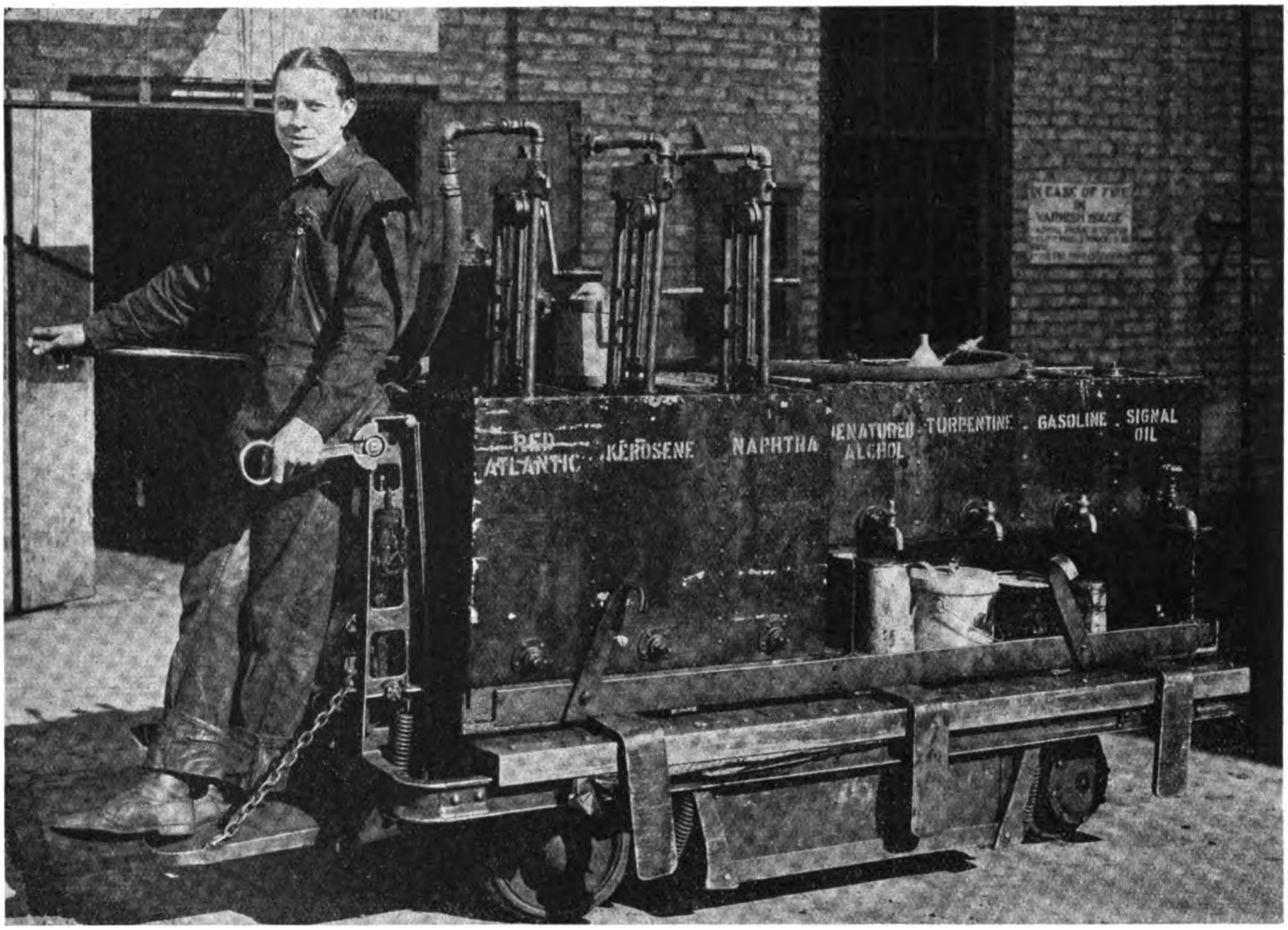
Crane Hoist Travel Limit Devices.—In discussing this paper, which was presented by Walter Greenwood, Safety Engineer of the Carnegie Steel Co., S. S. Wales, Electrical Engineer of the Carnegie Steel Co. spoke of the difficulty of preventing crane operators from "by-passing" or shunting the contacts of the limit switch so as to make it inoperative. He said that the elimination of this practice was not only a matter of education of the operators but also a factor which should be considered in the design of the limit stop. He criticised the use of two heavy weights on some of the limit devices, stating that there is a danger of the weights falling on someone below, and also of fouling the hoisting cable.

Mr. Wales stated that many of the limit devices are of too light construction and that trouble is experienced with burning of the contacts. On some of his cranes the upper travel clearance is so small that the limit stop is required to function on practically every shift. On these applications he finds that the contacts are too small.

Mr. Richardson spoke of having trouble with ropes and weights. He believes that most of the present day limit stops are too large; there is not room to mount them on the crane unless the operating ropes are run through several sheaves. He condemned this practice. He makes many of his own limit devices and prefers a reverse-current switch to one having a dynamic stop.

R. S. Shoemaker of the American Rolling Mill Co. disagreed with him on the size of limit switches. Mr. Shoemaker stated that he believes the limit stop should be large, expensive and the best that can be obtained. He has tried the practice of removing the stops from the hoist and making the operator responsible for accidents caused by running the blocks against the drum. In case the operator had two accidents he was automatically discharged. This practice was unsuccessful for it did not eliminate the accidents and was the cause of losing good men.

Ball and Roller Bearing Standardization.—At a business meeting of the association it was proposed that the manufacturers' 300 series of ball and roller bearings be adopted as standard by the Electric Power Club. This matter is now being considered by the latter organization.



This electric truck makes daily deliveries of oils and greases to twenty-two tool rooms. It carries two tanks with compartments of suitable size and furnishes everything carried in the oil house and required by the shop, including oils, naphtha, gasoline, turpentine, greases, and white and red lead.

How $6,929.06 Has Been Saved in the

Purchase, Storage and Distribution of Lubricants

During One Year by a Bulk Storage and Delivery System for the Manufacturing Departments of the Allis-Chalmers Manufacturing Company

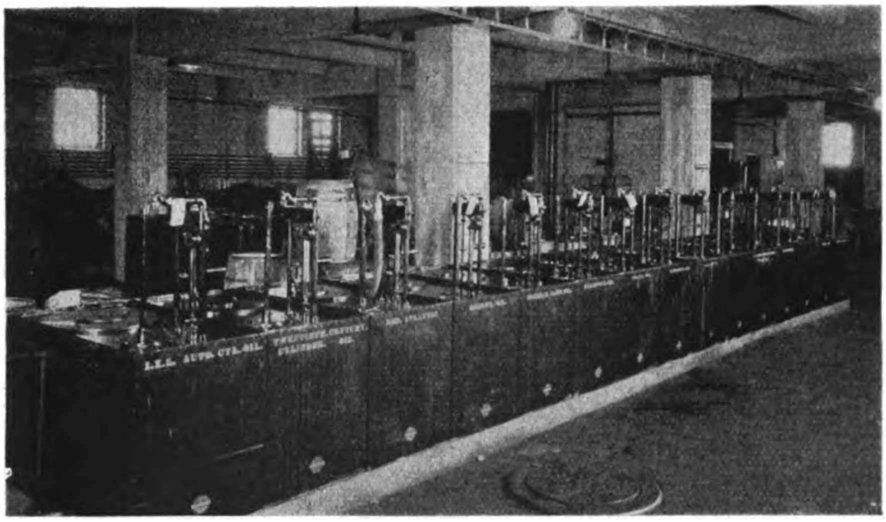
By HENRY FREEMAN

Superintendent Forge Shop, Allis-Chalmers Mfg. Company, Milwaukee, Wis.

IN THE summer of 1922, several committees were appointed by our assistant general works manager, to economize in supplies used generally throughout the shops. Success was so marked in the first drive on company tools and tool steel that other supplies were immediately made the subject of similar investigation. A committee, composed of Jas. Larsen, *Superintendent of Shops* 1, 2 and 3; Chas. E. Schnader, *Chief Power Plant Engineer;* R. S. MacPherran, *Chief Chemist,* and Henry Freeman, *Superintendent of the Forge Shop,* was appointed to study and improve the purchase, storage and distribution of oils, paints, and greases. At present West Allis Works boasts a fine system and the following is an account of the committee work leading up to it.

The survey of prevailing conditions revealed much opportunity for improvement. In the main oil house, where all stock is kept as it comes to the plant, there was evidence of wasteful, inefficient equipment. Of twenty-three service barrels, supported on a long rack, some were of wood, some of steel, some with faucets, some with valves and other fittings, and all of them were leaking more or less, all being wasteful. The same condition existed in the twenty-two tool rooms which carry the oil supply in the various departments in the works; every style of can, tank, barrel and drum that could be picked up was being used for storing and handling. In only one shop did we find them handling oil in an efficient way.

White lead was carried only in 100-lb. cans and in some departments this was six months' to two years' supply. Most tool rooms had an oversupply of cup grease in bad and dirty condition and in some cases unfit for use. It was very soon apparent that we needed a thorough housecleaning and that we must get fresh oil and clean grease to all users daily. This afterwards became the slogan of the committee, "Fresh Oil and Clean Grease Daily."



These fifteen 120-gal. tanks are located in the main oil house and are equipped with 1-gal. oil pumps. and hose connections. They take care of the heavy shop requirements.

After getting a line on the way these materials were being handled in our works, we began to investigate what other people were doing in this line. We visited plants having oil tank installations, some large, some small, but we found none very complete.

Then we visited shops that made large tanks and shops that made small tanks, and got all the information possible from them. We visited the supply houses and looked over the stocks of plain cans and pump cans of every kind and other supplies that might help us. We have corresponded with all the people who furnish oil installations and got their recommendations and prices. We visited all the large oil companies in the city and looked over their method of handling oil. Mr. MacPherran corresponded with the engineers of the large oil companies for information regarding the best way to handle the various varnish oils, and other volatile oils. No recommendations have been made until all information possible had been obtained and the practicability of the proposed plan carefully considered from every standpoint.

Saving in Core Oil Equals $404.25 in One Year

In the foundry, core oil was being bought by the carload in drums; these drums were unloaded by hand, stored in the gallery taking up valuable space, then man handled to the mixing room and lifted to a bench and tapped, taken off by hand when empty and later loaded on cars for return. To take care of this situation there has been installed underground a 12,000-gal. tank and purchase is now made by tank car lots. There has been installed in the mixing room a 5-gal. Milwaukee pump so that the men pump the oil as required and all drip returns to tank. This has resulted in a saving of 7.5 cents per gallon on tank car purchase, over purchase in drums. Our consumption in 1923 was 5,390 gallons, which made a total saving of $404.25.

Pump Equipment Installed in the Oil House

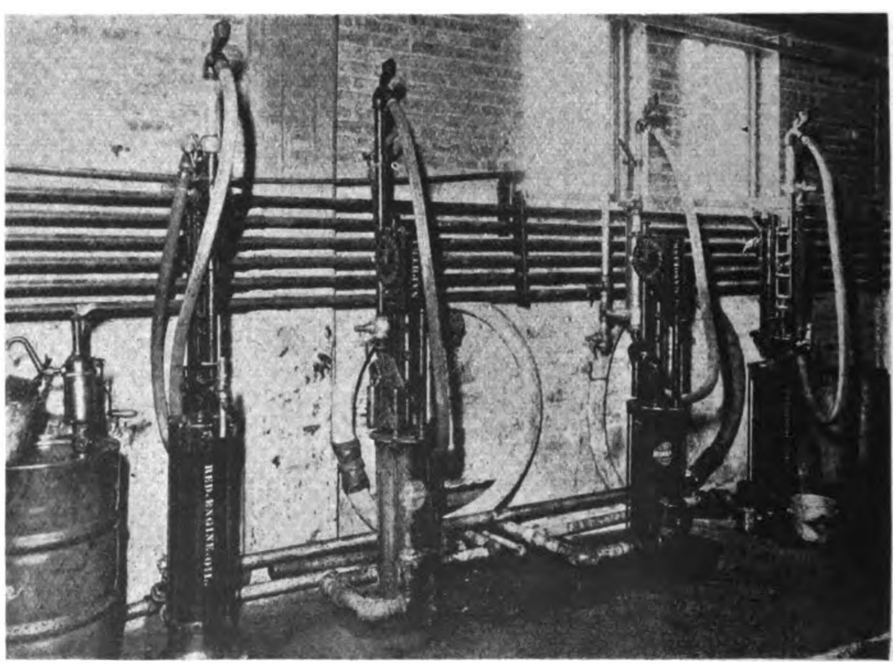
In the oil house there has been installed a Milwaukee battery system of fifteen 120-gal. tanks equipped with 1-gal. pumps and hose connections. These take care of the heavy shop requirements. There have also been supplied rotary barrel pumps so that they can pump direct from the original barrel or drum, the drip returning to barrel, instead of to an outside pan. They have been furnished with Marvel pumps for pumping and measuring grease from the barrel. This will take care of the heavy oils and light grease. There have been installed underground the following tanks: one 10,000-gal. tank for naphtha, one 10,000-gal. tank for lubricating oil, one 10,000-gal. tank for paraffine, and one 2,000-gal. tank for gasoline. These tanks are each connected to 5-gal. Milwaukee service pumps in the oil house. The naphtha pump is arranged to deliver this material to tanks on the second floor when required.

Standard Oil and Grease Cans for 22 Tool Rooms

Our twenty-two distributing tool rooms have been equipped with uniform pump cans of 3-, 5- and 10-gal. capacity. These cans have a drain back for the spill and drip and a standard-size grease pail with cover. All old grease cans, pails and other containers were collected and destroyed and in their place the tool rooms have been furnished with a standard 2-lb. can with cover. Limiting the men to this size can has compelled them to go to the tool room more frequently and get clean grease as needed.

They have also been supplied with a standard 2-lb. or 1-qt. oil can with cover soldered on, with a small hole in the top for a brush; this to be used on drill presses, where oil is required

These 5-gal. service pumps are connected to the underground oil storage tanks.



for drilling and tapping, also a standard can with hinged cover for white lead. These are given out on check to the workmen as required. All these cans are carried in stores to make replacements and keep the standard uniform in all departments of the works.

All unnecessary oil and grease cans in the shop cupboards and other odd corners have been eliminated and anyone needing oil, grease or white lead is required to go to the tool room, assuring a supply of fresh oil and clean grease.

Comparative Prices of Oils and Gasoline and Savings Under New Plan

Material	Used in 1923	Barrel per Gal.	Tank per Gal.	Saving per Gal.	Total Saving
Kerosene	4,605	.113	.073	.04	$ 184.20
Gasoline	25,418	.167	.127	.04	1,116.72
Naphtha	35,439	.202	.148	.054	1,913.70
Paraffine Oil	10,671	.146	.073	.073	778.98
Red Engine Oil	14,611	.199	.125	.074	1,081.21
Core Oil	5,390	Differential		.075	404.25
					$5,579.06
Eliminating visits to oil house					1,350.00
Total direct saving for one year					$6,929.06

Daily Delivery of Oil and Grease by Electric Truck

There has been installed a daily delivery system by electric truck. This truck has been especially designed and built to meet the requirements. It has two Milwaukee tanks of five and three compartments respectively of 10-, 15- and 20-gal. capacity and carries everything in the way of oils, naphtha, gasoline, turpentine, greases, white lead and red lead; in fact some of everything that is carried in the oil house and required by the shop. This truck makes a daily trip to each of the twenty-two distributing tool rooms in the works and delivers whatever they may require and takes the tool room tender's receipt for the supplies. The driver makes the round trip in two to two and one-half hours. The truck returns to the oil house where supplies are replenished and everything is made ready for the next day's run.

It is interesting to make a round trip with the oil truck and note the business-like way and the dispatch with which supplies are ordered and delivered. Wherever possible, carrying the oil from the truck tank to tool room tank has been eliminated and the tool room tanks are so arranged that oil can be pumped directly from the truck tanks. For the special supplies or those used only occasionally and in small quantities delivery is made in their own cans as required. This part of the service has given very general satisfaction throughout the departments.

Previous to this time there were on the average fifty-five men from all departments calling at the oil house for supplies every day. Since the system of delivery by truck has been installed this has been reduced to five or less per day, a reduction of fifty visits per day. A conservative average of each man's time per visit would be about 15 min.; then $50 \times \frac{1}{4}$ hour = $12\frac{1}{2}$ hours, less $2\frac{1}{2}$ hours for delivery time by truck leaves a net of 10 hours daily, 300 times (for working days) at 45 cents per hour equals more than $1,350.00 per year. This is a very important saving together with the fact that we are delivering "fresh oil and clean grease daily."

Standard oil containers provided for tool rooms.

Twenty-two distributing tool rooms have been equipped with pump cans of 3-, 5- and 10-gal. capacity. They are also provided with standard 2-lb. or 1-qt. oil cans with a small hole in the top for a brush, for use in drilling and tapping operations, and standard 1-qt. cans for white lead. Grease is furnished in standard 2-lb. cans with cover, to keep it fresh and clean.

Being able to go into the market for tank car lots of lubricating oil, naphtha, kerosene, paraffine, gasoline and core oil, a considerable saving has been effected over purchase by barrel or drum. A summary of this saving over a period of one year would be about as shown in the above tabulation which also gives the amounts used and prices paid for the different materials.

Difference Between Total Expense and Saving for One Year

Then there is the indirect saving by elimination of the daily handling of barrels, the loss by side- and corner-cling to the barrel is also eliminated; this is figured by oil engineers at 2 per cent. The cost of installing the five underground tanks at the oil house and foundry with pumps and hose connections complete, exclusive of the tanks, amounted to $4,164.48.

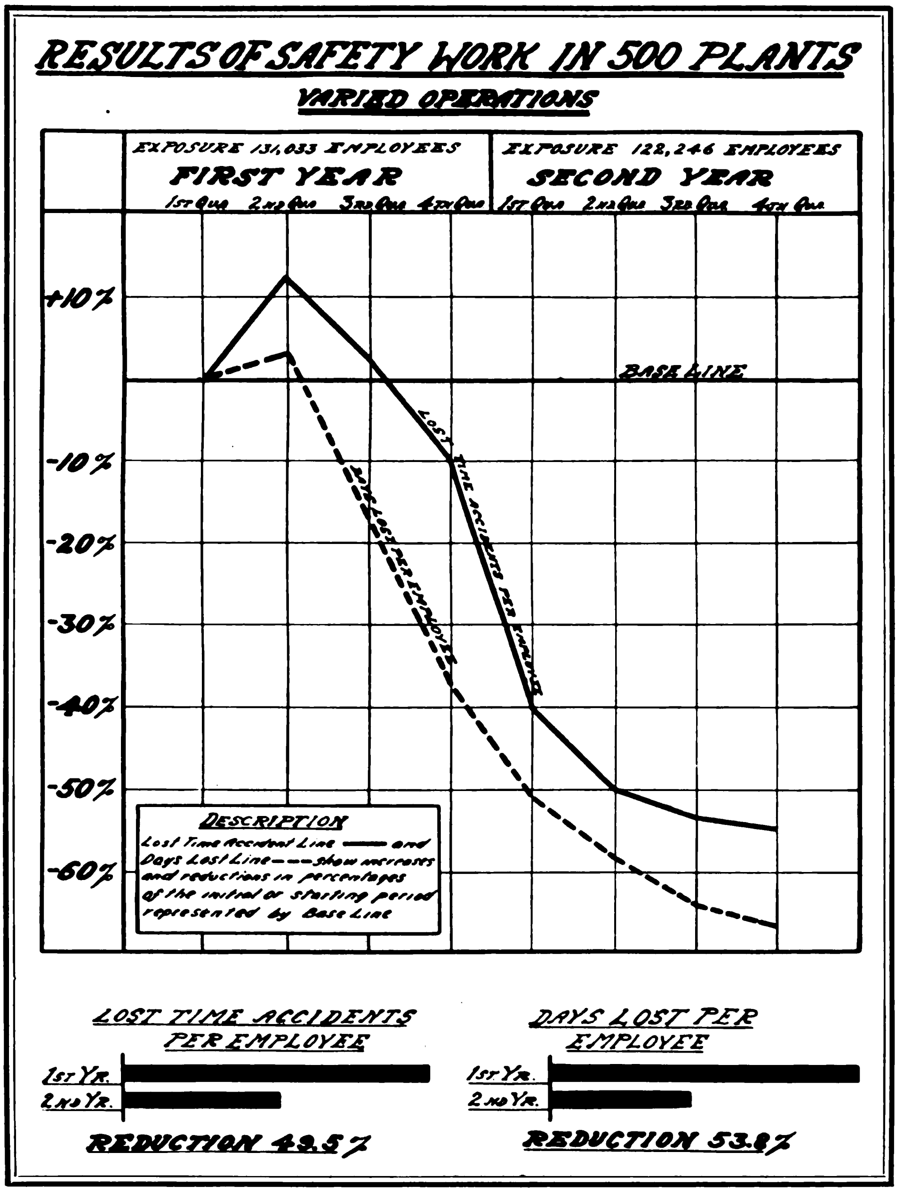
Cost of large underground tanks, installation and equipment at oil house and foundry	$4,164.48
Cost of equipment and installation of truck tanks, pump tanks at oil house and tool rooms complete	3,226.00
	$7,390.48
Total direct saving for one year	6,929.06
Difference between total expense and saving for one year	$ 461.42

THIS IS THE second article on Industrial Safety by Mr. Donald in which he emphasizes the importance of the centralization of the work in the following statement: "If the Maintenance Engineering Department is not the center of accident control, it is at least its chief ally, for all upkeep must regularly be referred to it. One advantage of placing accident prevention in this department is the avoidance of irritation which frequently results when workers or executives of one department presume to examine and criticize conditions in another. Another advantage is that the primary requisite for a reduced cost of accidents is a well-kept plant."

Some Practical Pointers on

Directing Attention in Safety Work

With Reference to Standardized Safeguards and Some of the Details of Making Inspections



This chart shows what safety work has accomplished in 500 plants.

This chart shows the per cent of increase and decrease of "Lost-Time Accidents" and of "Days Lost" per employee in a composite summary of 500 plants engaged in various kinds of work. Although at first there seemed to be a slight increase in accidents, after the safety work got well under way the reduction, as shown by the slope of the curve, was very pronounced.

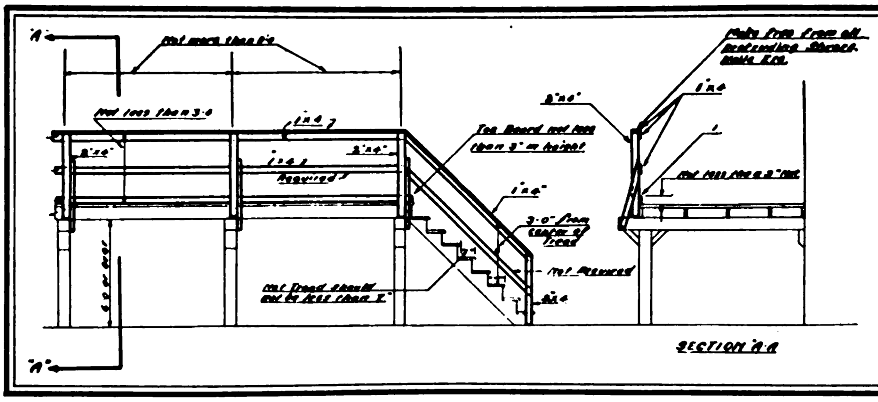
By H. W. DONALD
District Manager of Engineering, American Mutual Liability Insurance Company, Boston, Mass.

HEALTH AND SAFETY of the employees in the industrial plant, large or small, calls for as intelligent and as systematic attention as the upkeep of machines, for there has been a steady advance and broadening of the standards of personal health and safety with each advance in industrial development. With accident prevention in view a human interest is added to the daily grind of fixing up an inanimate plant and machines. Human safety when once considered and understood stimulates the interest of all concerned and in arising to the needs of their fellow-workers all are watchful of slack or wear in plant and equipment.

In the larger industries, a division of the repair work is necessary. With a systematic plan of reporting, housekeeping features are carefully inspected and accurately controlled. Sanitation and cleaning, for instance, are frequently the work of separate departments, with considerable economy and increased efficiency, for with the old system of sanitation within the departments the areas in between were a "no man's land" for the janitor's crew. The nurse or hospital staff inspects and reports on this question and keeps an accurate check of sickness and industrial disease in addition to the record of accidents.

If the *Maintenance Engineering Department* is not the center of accident control, it is at least its chief ally, for all upkeep must regularly be referred to it. One advantage of placing accident prevention in this department is the avoidance of irritation which frequently results when workers or executives of one department presume to examine and criticize operating conditions or methods in another.

It is logical, therefore, for the *Maintenance Department* to centralize so-called safety work and it is consequently necessary that those responsible for it should be acquainted with the special industrial standards and the requirements of state laws. For practical needs, the "Handbook of Industrial Safety Standards" (distributed by many insurance companies) has been prepared to cover the most common features and coincides as nearly as possible with the largest number of state regulations. It is



The use of approved types of safeguards reduces the accident premium.

Whenever an inspector for a liability insurance company inspects a plant he always records whether the guards follow the approved standard and if so the plant receives recognition in reduced cost of insurance. The sketch here shows standard wood construction of railings and toeboards for stairways and platforms. This is one of the many standards which have been worked out by the engineers of the insurance companies and are available for those who wish to follow them.

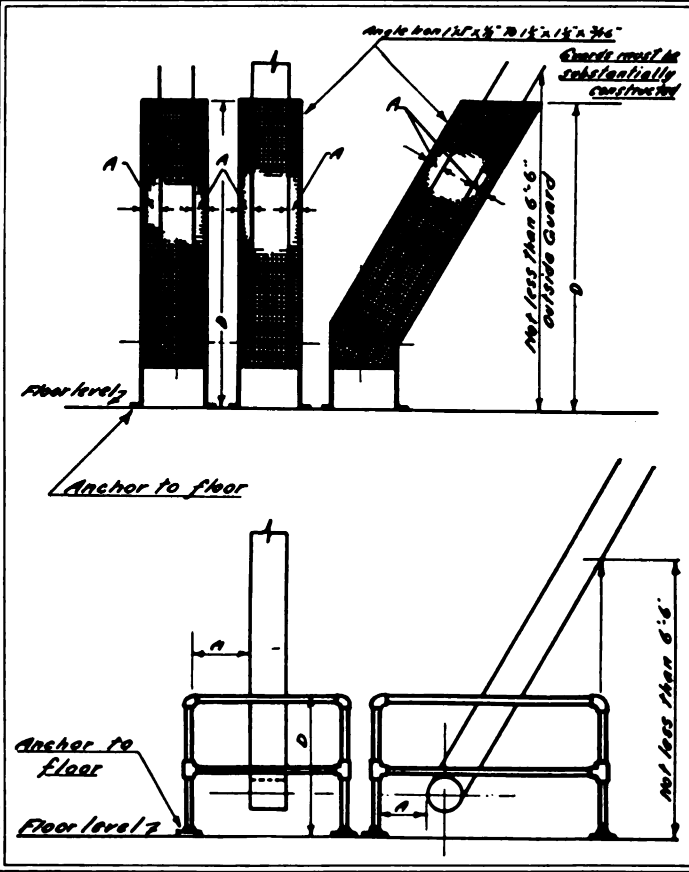
accepted by Workmen's Compensation Bureaus in Maine, New Hampshire, Vermont, New York, Pennsylvania, Maryland, Alabama, Louisiana, Tennessee, Minnesota, Massachusetts, New Jersey, Delaware, Virginia, Georgia, Texas and Kentucky. Other states have their own standards which may be obtained from the factory inspectors or other bureaus in that state responsible for their enforcement. Also a large number of other associations and organizations have issued codes or recommended practices. Perhaps one of the best known is the "National Electrical Code" issued by the National Board of Fire Underwriters, which embodies the recommendations of the National Fire Protection Association. The National Safety Council, Chicago, Ill., have also issued a number of "Safe Practice Pamphlets" which take up the construction and installation of guards and equipment as well as safe practices in the operation of equipment. A few of the subjects covered are: Ladders, stairs and stairways, cranes, belts and belt guards, oiling devices and oilers, scaffolds and many others, including altogether about sixty subjects.

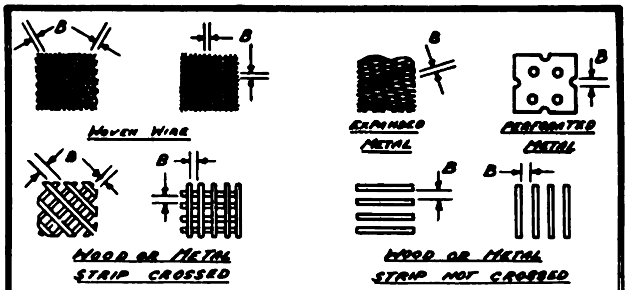
A lack of appreciation of the value of these standards by plant maintenance men has resulted in the insurance inspector (whose duty it is to establish a physical rating for each plant) finding an endless variety of sub-standard guards. So frequently is this the case that a special column is placed in the report blank for notations of this feature, and considerable physical credit is lost from this cause, when as a matter of fact a fully standard guard would not require any more labor and little more material to fulfill all requirements.

These standards have been a matter of steady growth. Starting in Europe, almost with the development of power machinery, they have constantly been revised and adjusted—not alone on theory or fancy of the compilers and inventors—but step by step as human suffering and sacrifice has pointed the way.

Human fallibility recorded in accident analysis shows failure of the human mind repeatedly under the same conditions, or at similar points in a process. Accidents at first attributed to negligence come to be so often repeated as to indicate the normal human reactions. No further argument is necessary. The process should be changed or the machine guarded.

Besides the aid to be had from the





Material	A Clearance from Belt at all Points	B Largest Mesh or Opening Allowable	C Minimum Gauge [U.S. Standard] or Thickness	D Minimum Height of Guard from Floor Level
Woven Wire	Under 4"	½"	½" - #20	6'0"
	4"-15"	2"	2" - #12	5'0"
Expanded Metal	under 4"	½"	½" - #18	6'0"
	4"-15"	2"	2" - #13	5'0"
Perforated Metal	Under 4"	½"	½" - #20	6'0"
	4"-15"	2"	2" - #14	5'0"
Sheet Metal	under 4"	—	#22	6'0"
	4"-15	—	#22	5'0"
Wood or Metal Strip Crossed	under 4"	½"	Wood ¾"	6'0"
	4"-15"	2"	Metal #16	5'0"
Wood or Metal Strip not Crossed	under 4"	½" Width	Wood ¾"	6'0"
	4"-15"	1" Width	Metal #16	5'0"
Std Rail	Min 15" Max 15"	use 1½" Pipe or heavier		3'6"

The above standard recommendations for belt guards may also be used for rope drives.

The table above shows the standards from which the guards at left may be made, as approved by the American Mutual Liability Insurance Company, Boston, Mass.

Industrial Safety Standards and existing codes, a great deal must be accomplished through the application of common sense and inventive genius.

Stamping presses, for instance, require a different guard for almost every change of set up, as far as the finger hazard or point of operation is concerned. Yet, guards are everywhere more generally used, and we find automatic feed and throw-out devices of a most ingenious order developed in some plants, making an accident practically impossible and greatly speeding production. Intensive study is necessary. Accidents with this equipment are not always caused by carelessness on the part of the employee.

Particular attention should be given to the guarding of the parts of machinery in motion which are of easy access, on aisles or corners or in narrow alleys where machines have been crowded together. Guards should prevent contact with moving parts, either from persons falling against them, backing into them or reaching through them, so that where necessary to place guards near points of dangerous contact the mesh or apertures through the guard must be correspondingly small, according to the distance of the guard from the point of danger.

Materials used depend frequently upon what is available. Consideration should be given to dust-collecting tendencies of partially closed places and consequent fire hazard, to the stability of the material to withstand damage from trucks and moving material and to corrosion in acid atmospheres.

In addition to moving equipment, which incidentally accounts for only one-fourth to one-third of all accidents, the next most important consideration might be given to so-called openings in walls or floors, and the need of handrails on all stairs of three or more risers. Even though wall openings in upper stories may be used only occasionally, they should have an auxiliary gate hinged and latched in place, when opened in summer.

Elevators, machines, gears and shaftways have many special guards and special requirements, which vary somewhat in different states. Requirements of state codes should be compared in all cases.

In considering the safety of individual machines and for insurance rating purposes, they should be regarded from three aspects: First, the means of applying power, belts, shafts or gears; second, so-called "other moving parts"; and third, in the case of over 100 specific machines, the "point of operation." Proper guarding will yield credit in each of these three particulars, and if to be guarded at all it is well worth the effort to fulfill the simple requirements of the Industrial Safety Standards so accurately that credit may be obtained, as in the lately revised schedule rating plan "point of operation" is given the largest consideration.

Value of Inspection in Accident Prevention and Maintenance

But things unseen are at times more potent than those visible. Wear-and-tear bores from within as well as from without, and the art of foreseeing latent defects and wear before they become serious and kill someone or stop the plant, is a more important part of maintenance work than making repairs after the damage is done.

How shall latent defects and failure be determined? It is vital that a systematic procedure be established. Programs of inspection at regular intervals are part of all upkeep as well as periodic oiling, periodic testing and adjustment of nuts or fastenings and periodic overhauling of all machines. Inspections of boilers, elevators, fly wheels, turbines and fire equipment are similarly important features, but why stop there? Unless the factory is so small that outside labor is called in

This standard form is recommended for reporting safety inspections.

This questionnaire type of report is similar to that used by the inspectors for the insurance companies. Plant men will find it useful in that it shows what is to be looked for and so decreases the possibility of overlooking important hazards. The reverse of the form is reproduced on the opposite page.

QUESTIONNAIRE

Plant Safety Inspection Report

This form to be used in reporting inspections made by Safety Inspector (weekly), The Workmen's Committee (monthly), General Committee (monthly). Original to be kept on file.

The man or men assigned to the safety work in this plant shall familiarize themselves with the requirements of the Handbook of Industrial Safety Standards and shall make a thorough inspection of the entire plant at the required intervals; examine carefully the condition of all buildings, stairs, fire appliances, boilers, engines, transmission machinery, belts, pulleys and working machines; note carefully the condition of present guards and give special attention with the view of installing additional safeguards. Note carefully the violation of safety rules and need of additional rules, also look for unsafe practices. New recommendations must be written out in full in space provided under each heading. The questions are only for your guidance. Make recommendations covering all unsafe conditions that it is practical to eliminate.

Recommendations shall be numbered consecutively beginning a new series each year.

Name of Assured .... Location ....

Names of Inspectors or Committee ....

.... Date of Inspection ....

.... Date of last Inspection ....

Recommendations Should Be Numbered Consecutively in This Column

(A) **Fire Hazard (110):** Are all fire fighting appliances ready for immediate use? Are fire exits and fire escapes clean and in good condition? Is plant kept free from excess inflammable waste and rubbish? (403). Are explosive materials properly handled and stored?

(B) **Floors (120), Floor Openings (132), Wall (134), and Hoistway Openings (136):** Are all openings properly guarded? Note condition of floors; see that floor surface is free from protruding nails, splinters, holes, slipperiness, unevenness and loose boards.

(C) **Stairs (140):** Are hand rails sufficient and substantial? Are stair treads in good condition and is light sufficient? **Ladders:** Are they in good repair; are safety feet needed?

(D) **Elevated Runways and Platforms (150):** Are they in good condition, clear of obstructions and provided with handrails and toe boards? Is material piled safely away from edge?

(E) **Transmission Equipment (320):** Are oiling platforms, ladders, belts, pulleys, shafting, set screws and other protruding revolving parts guarded?

(F) **Machine Hazard (360):** (a) State what guards are found not in use, and where guards should be provided. This should include all gears, sprockets, chains, belts, pulleys, clutches, shafting, spindles and all other dangerous revolving or reciprocating parts. (b) Are there any points of operation on these machines which can be more fully guarded?

A. M. L. 22 **To be kept on file at plant and shown to the Rating Inpector when he calls.**

for pick-up or overhauling, some further program is necessary.

When a spirit of intelligent regard for modern methods of accident prevention is active within the plant, due consideration is given to the guarding of all new equipment. It is generally much cheaper to buy a machine with the guards provided than to endeavor to supply them later. All machine makers have considered the safety of their machines, and if safeguards are specified the full standard of protection may be secured.

A surprising number of loose ends are allowed to take care of themselves until someone steps through a hole in the floor or into a vat; and his contributing negligence is blamed rather than lack of systematic pick-up.

This is the remainder of the questionnaire plant safety inspection report shown on the opposite page. It is recommended that these reports be made weekly by a safety inspector for the plant, and by a workmen's committee and a general committee monthly.

Questionnaire Method of Reporting Plant Inspections

A brief questionnaire, similar to the one reproduced here, for this purpose has been in use for several years past by all Compensation Companies or Bureaus. A questionnaire form of inspection report is necessary in order to obtain a comprehensive view of the entire subject. A special form applicable to the particular plant should be made up where considerable difference exists, omitting items which do not apply and adding or amplifying others which do.

Recommendations for all repairs should be entered in respective headings and numbered, and where sufficient recommendations result a separate list should be kept which can the more readily be followed up and checked off as the work is completed and with which the order slips to various repair departments may be compared.

With the "old timer" it is much easier to go out with a hammer and eliminate the difficulty at once, rather than to report it, and only an occasional record results. This fails in the purpose of developing interest in work accomplished and in developing a record which can later become the basis of estimate of future maintenance requirements which become more and more important as the age of the plant increases.

There is also a habit of refraining from reporting items requiring unusual consideration, such as, lighting, ventilation, re-arrangement of machines as well as structural building changes. There is a feeling that the record will look bad or that it would be useless to record items beyond the reach of immediate accomplishment. This is an erroneous point of view, as these ideas will be invaluable when the opportunity comes for larger development.

With the foregoing record made at least weekly in plants involving manufacturing hazards and employing over a hundred employees, a very considerable start has been made toward the accident control plan which has been applied most successfully in a great number and variety of industries.

Recommendations Should Be Numbered Consecutively in This Column

(G) **Elevators and Other Hoisting Equipment (170):** Note condition of signal system, cables, safety devices, gates, car and shaftway protection, car and landing lighting.

(H) **Power Traveling (Bridge) Cranes (100):** Note condition of footwalk, railing ladders and safety appliances. Is signal used to guard workmen? Are chains, slings and hoist cables inspected?

(I) **Electrical Equipment (212):** Note condition of switchboard, transformers, wiring and controlling and operating apparatus and see that they are properly protected or isolated.

(J) **Boilers, Pressure Apparatus (200), Steam, Gas and Oil Engines (300):** How often blown down and washed—are safety valves and water gauges tested daily—are speed limits of engines tested daily? Are moving parts safeguarded?

(K) **Handling Material:** Trucking passageways, light, obstructed view at corners, railroad access, hoists needed, piling and storing, yard conditions, nails, glass, sharp edges, hand tools, acids, caustics, gases, dusts.

(L) **First Aid:** Note if sufficient supplies, cleanliness, easy access, stretcher. Goggles, respirators, foundry shoes and leggings—are they available?

(M) **Sanitation:** Note light, windows clean, lamps need shades, ventilation, drinking water, washing facilities, clothes lockers, condition of toilets, cuspidors. General housekeeping.

(N) **Bulletins** **Quantity Posted**

(O) **Accidents Investigated:**
Date **Name** **How It Happened**

(P) **Recommendations Summarized. Individual Numbers** **Total**

I. Submitted.
II. Completed.
III. Under progress.
IV. Not begun.

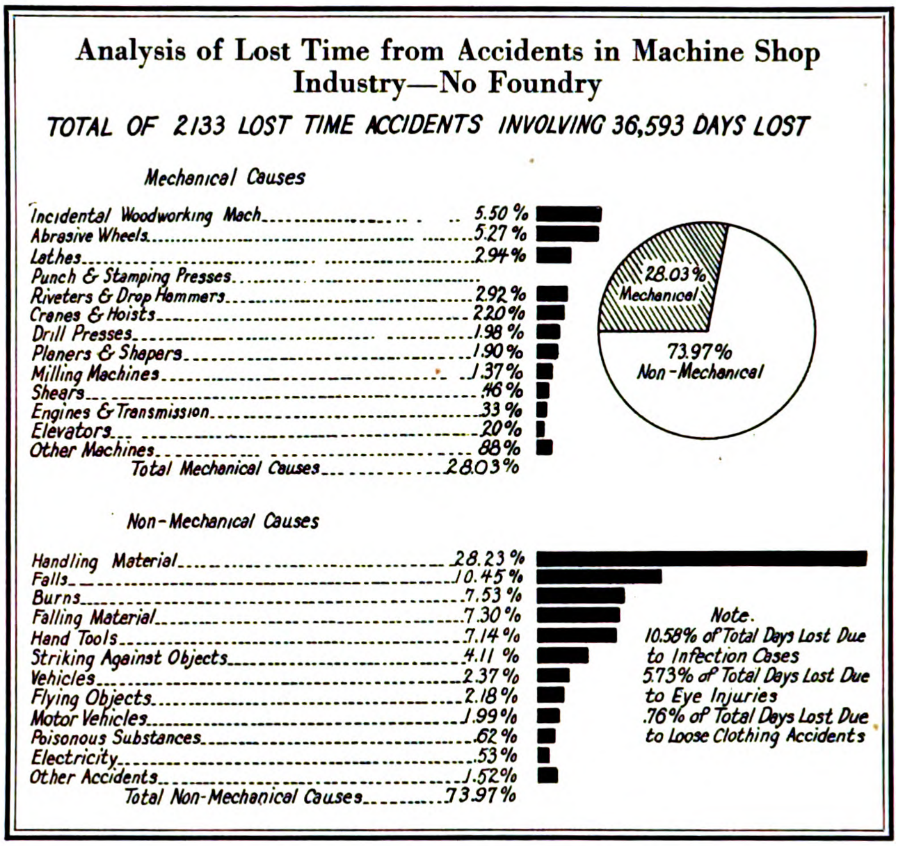
Why It Is Necessary to Do More Than Provide Safeguards

It has been long known that after the fundamental guarding has been accomplished something more was necessary to prevent accidents, as only one-fourth to one-third of all accidents might be attributed to machines. A brief consideration of the various causes of accidents shows that the workmen need instruction in the dangers of their work; that the thoughtless should be reminded and that in order to obtain the co-operation of the workers in an effort to save them from suffering, their active participation in an accident prevention routine is necessary.

The full plan of accident control or safety organization, as developed in the Industrial Safety Standards, has warranted a direct reduction in schedule rate of 5 to 15 per cent. This credit is only a preliminary benefit, as through reduction of losses the experience features of the present rating plan allow credit for

One of the first steps in accident prevention is to make an analysis of the causes of accidents in your plant as is done for an industry here.

The prevention of accidents from non-mechanical causes may best be obtained through education and training of the men in the importance of safety because the larger proportion are the result of carelessness and so cannot be prevented by safeguards. Part of the accidents from mechanical causes can be prevented by guards but here education is also important. "The best safeguard is a careful man," is an axiom of industrial accident prevention. Handling material is the largest single cause of accidents.



reduced accident loss amounting in some cases to 40 or 50 per cent.

Plans for safety organization are developed according to the size of the plant based on the number of employees, and generally center about the maintenance departments. Plants containing up to 150 employees, with normal manufacturing dangers, require a Supervisory Committee in addition to the weekly inspections previously described. Supervision of maintenance would exist in any case, and for the purposes here contemplated it is required that a committee of three or more of those in authority meet once a month and review inspection reports and accidents and authorize action.

Management and Employees Must Both Show Interest in Safety

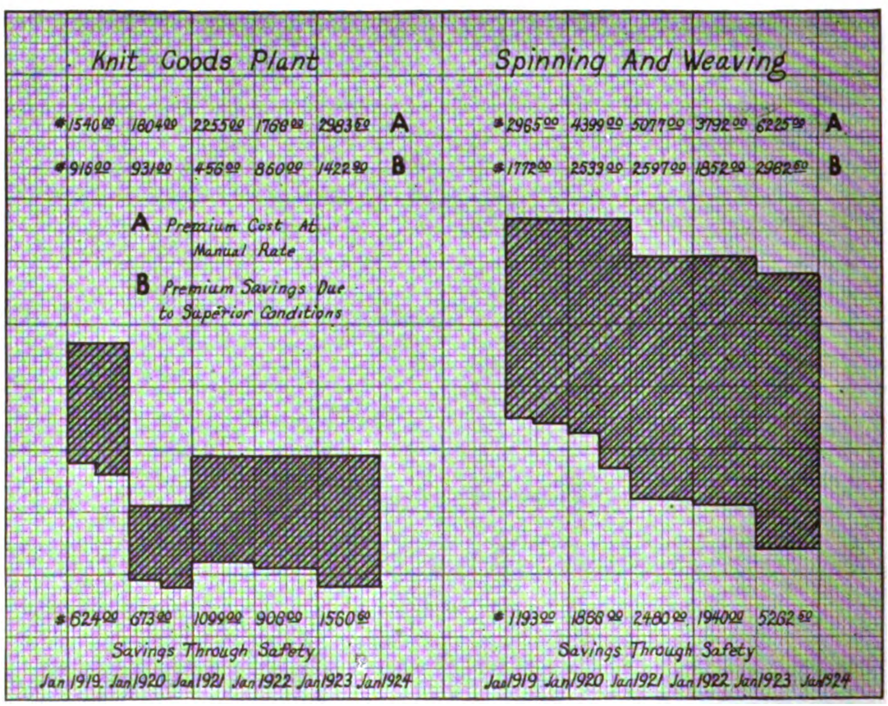
An interest in, or special consideration of, safety at least once a month, on the part of the management, is a condition quite as necessary as the interest of the workers. In plants up to 500 employees, a monthly inspection by the Committee (or by selected members of it) should be added and some method should be used at least twice a year to speak to the employees in groups or as a body, on accident prevention questions.

Credit for organization in plants of over 500 employees, substitutes a Workmen's Committee of inspection for the single committee. Other details are retained.

The primary requisite for reduced cost of accidents is a well-kept plant.

That means systematic maintenance. last and the repair man is obliged to "run in" the guarding of machines Too often safeguarding is left to the here and there when he gets a chance after supposedly more important machine changes have been made. He will do what he is told in all events and it depends on management to set up a definite system that will follow up safety recommendations.

After that, with a lowered ratio of mechanically caused accidents, it is time to attack the non-mechanical accidents through education, but always and forever there will be that need of inspection, follow-up and repair—the duty of maintenance. The repair man stands in the way to offset the ever-rising tide of the cost of industrial accidents, if you give him a chance. The responsibility rests with the management.



Savings made in two departments as a result of organized safety work.

The shaded area shows the reduction in premium for liability insurance in a textile mill after safety had been conducted on an organized basis. The top line *A* of the shaded area represents the amount of insurance at the manual rate for average safety conditions. The lower line *B* of the shaded area shows the actual premium paid after the safety work was put on an organized basis. The actual savings in dollars are given just below and are represented by the shaded areas.

Step-by-Step Methods of

Laying Out Wave Windings for A.C. Motors

Complete With Diagrams Showing Windings at Different Stages of a Job Together With Details of Series-star and Series-delta Connections and How The Coils and Sections may be Paralleled

THIS is the second of a series of articles on alternating-current wave windings. The first article, which was published in the September issue, explained how to lay out and construct a wave winding for two-phase and single-phase stators having two-layer windings. This article explains how the construction and rules are applied to three-phase windings of this type. Winding more than two coils per cell and methods of paralleling coils are also discussed. A succeeding article will give short-cut methods and tabulations of data for use in laying out this type of winding.

By A. C. ROE

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THE previous article in the September issue explained how to lay out and construct two-layer wave windings for two-phase and single-phase stators. The construction and rules as applied to three-phase windings of this type, will be taken up in this article.

We will first lay out a series-star winding for a four-pole, three-phase stator having twenty-four slots and twenty-four coils. As was done in the previous article, the data and calculation will be tabulated as follows:

(1) Number of slots—24
(2) Number of phases—3
(3) Number of poles—4
(4) Number of coils—24

The first four items are taken from the data given in the description of the winding in the preceding paragraph.

(5) Number of coils per slot equals total number of coils divided by total number of slots, or $24 \div 24 = 1$

(6) Number of sections, according to *Rule 3* (given in the box on page 486) will be equal to twice the number of phases, or $2 \times 3 = 6$

(7) Number of coils per section equals total number of coils divided by total number of sections, or $24 \div 6 = 4$

(8) Number of coils in a series, according to *Rule 1*, is equal to one-half the number of poles in the winding, or $4 \div 2 = 2$

(9) Number of series of coils in a section equals number of coils per section (see item 7) divided by number of coils in a series (see item 8), or $4 \div 2 = 2$

(10) Number of coil groups, according to *Rule 4*, equals number of phases times number of poles, or $3 \times 4 = 12$, making twelve pole-phase groups

(11) Number of coils per group equals total number of coils divided by the total number of groups, or $24 \div 12 = 2$

(12) Number of coils per phase equals total number of coils divided by number of phases, or $24 \div 3 = 8$

(13) Winding pitch equals total number of slots divided by half the number of poles, or $24 \div 2 = 12$; that is, the total winding pitch will be 1-and-13

(14) The back pitch is equal to one-half the winding pitch, or $12 \div 2 = 6$, which is a back pitch of 1-and-7

(15) The front pitch is equal to the total winding pitch minus the back pitch, or $12 - 6 = 6$, which is a front pitch of 1-and-7.

The winding resulting from the above data and calculations, and in particular from items 6, 7, 8 and 9, will have two sections per phase or a total of six sections, each section having four coils arranged in two series of two coils each. A left-hand winding will be laid out.

The first step is to draw the four circles and slots as was explained for a two-phase winding in the previous article. These four circles are shown in light lines in Fig. 1. The two inner circles are to mark the limit of the slots and the two outer circles are to mark the limit of connections between slots. Since there are two coil sides in each slot for this winding, two lines are drawn in each slot, the bottom coil side being represented by a dotted line and the top coil side being represented by a full line. Starting with a top coil half or conductor in any slot, say slot *2*, draw in the lead A_1 as shown in Fig. 1.

Counting in a clockwise direction from slot *2*, a distance equal to the back pitch of 6, we arrive at slot *8*. Slots *2* and *8* are to be connected on the back by the connectors as is shown in the diagram. The bottom coil half is used in slot *8*. Counting in a clockwise direction from slot *8*, a distance equal to a front pitch of 6, we arrive at slot *14*. The front end of the bottom coil half in slot *8* and the front end of the top coil half in slot *14* are to be connected as is shown in the diagram. In a similar manner we connect the back end of the top coil half in slot *14* with the back end of the bottom coil half in slot *20*. This is the end of the first series of two coils in the first section of the first or *A* phase. Since there is always a short pitch between the end of one series and the beginning of the succeeding series, the front end of the bottom coil half in slot *20* is connected to the front end of the top coil half in slot *1* as is shown in Fig. 1. These two coil sides are a short pitch of five slots apart.

Continuing on through the second series and using a front pitch and back pitch of 6 we connect slots *1* and *7* on the back, slots *7* and *13* on the front, and slots *13* and *19* on the back and carry the front end of slot *19* to R_1. This is all shown in Fig. 1. This finishes the first section of the *A* phase.

The location of the R_1 lead, that is, the end of the first section, could have been determined from *Rule 7*. According to this rule the R_1 lead will fall behind or ahead of the A_1 lead and a number of slots that is equal to the front pitch plus one less than the number of coils per group; that is, in the case of this winding the R_1 lead will be a distance away from the A_1 lead, measured in a counter-clockwise direction, of 6+2–1=7 slots. Counting in a counter-clockwise direction from the slot in which the A_1 lead is connected, that is, slot *2*, a distance of seven slots, we arrive at slot *19* which, as we found before, was the location of the R_1 lead.

The R_2 lead, that is, the start of the second section, can be located by

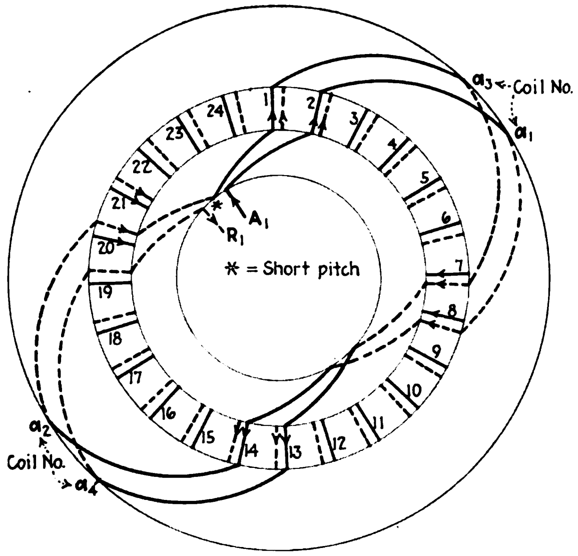


FIG. 1

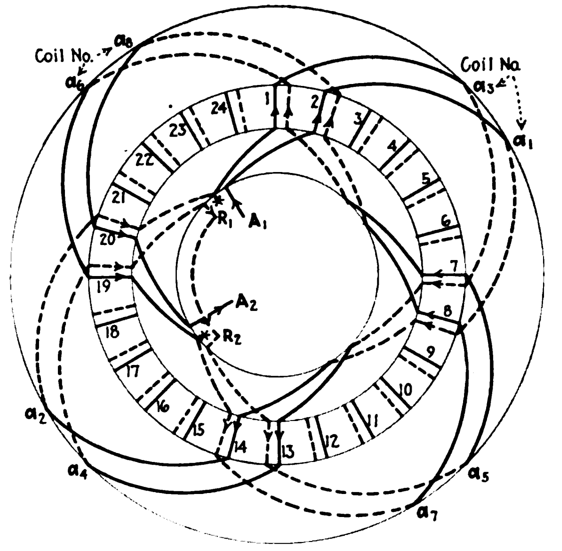


FIG. 2

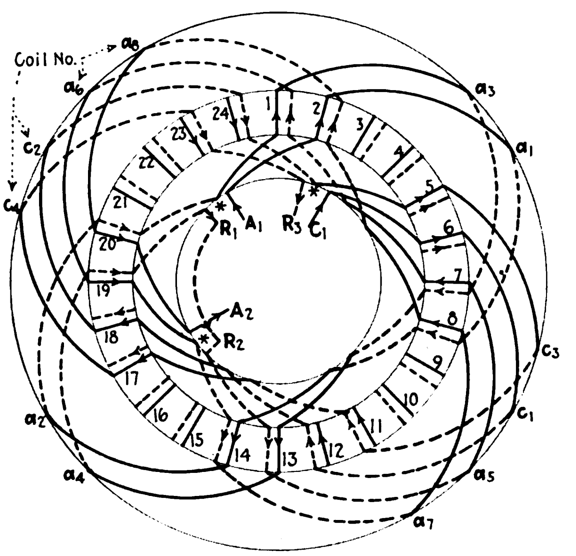


FIG. 3

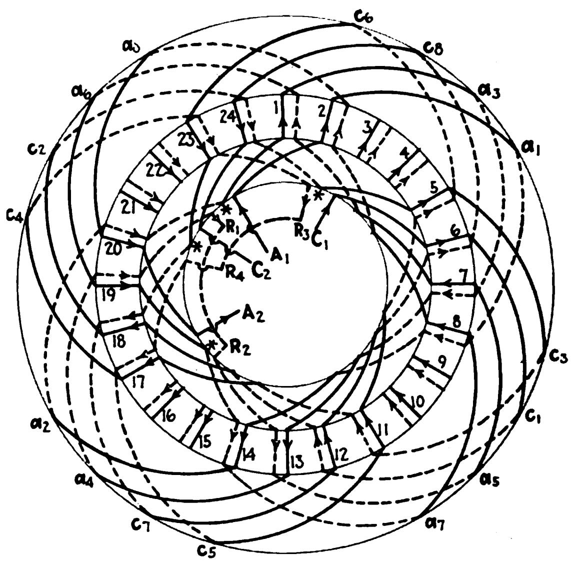


FIG. 4

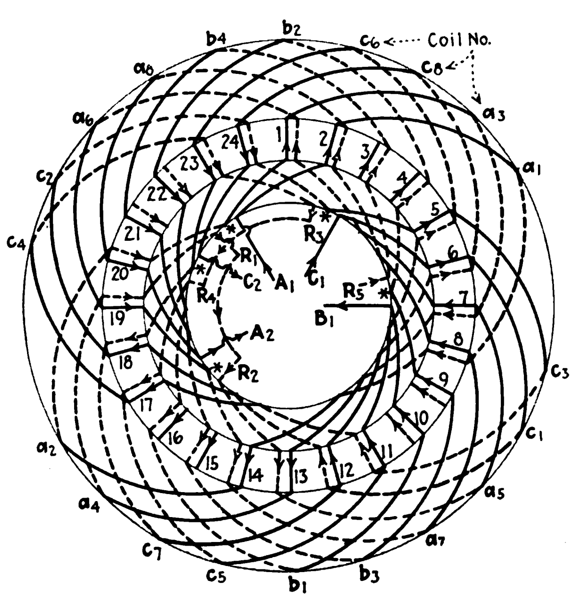


FIG. 5

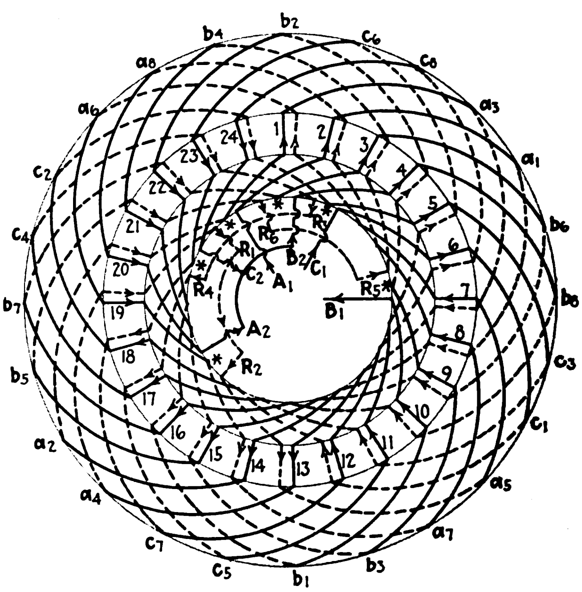


FIG. 6

Figs. 1 to 6—Progressive stages in the construction of a four-pole, three-phase, series-star wave winding for an induction motor.

This winding is a two-layer winding having twenty-four slots and coils with two sections per phase, each section arranged in two series of two coils each. The first section of the *A* phase is shown in Fig. 1. The *A* phase has been completed in Fig 2. Fig 3 shows the *A* phase together with the first section of the *C* phase. Fig. 4 shows the *A* and *C* phases complete. In Fig. 5 the first section of the *B* phase has been added. Fig. 6 shows the complete winding diagram for the stator.

means of *Rule 8*. According to this rule, the R_2 lead will fall in a slot that is a distance of one front pitch or six slots, measured in a counter-clockwise direction, from slot *19*; that is, it will fall in slot *13*. This is shown in Fig. 2.

According to *Rule 9*, for this winding the A_2 lead will be located in a slot that is one front pitch, measured in a counter-clockwise direction, from A_1. Counting a distance of six slots in a counter-clockwise direction from slot *2*, we arrive at slot *20*, which is the location of the A_2 lead. According to *Rule 10*, since A_1 connects to a top conductor, A_2 will also be connected to a top conductor; therefore, A_2 will connect to the top conductor in slot *20*.

There are several considerations affecting the determination of the starting point of the next phase. Since there are twenty-four slots and four poles there will be $24 \div 4 = 6$ slots per pole. Of the six slots for each pole, two slots will be occupied by the *A* phase, two by the *B* phase and two by the *C* phase. All of these slots must have the same polarity; that is, at any one instant the current must be passing through all six slots in the same direction. In Fig. 2, the *A* phase was started in slot *2*. The direction of flow of the current is taken to be into the winding on the lead A_1; hence the arrows on A_1 and the top conductor in slot *2* will be in the direction shown. Tracing through the remaining slots of the *A* phase the arrows are placed in the *A*-phase slots in the direction of travel, as is shown in Fig. 2. This determines the instantaneous polarity of all the *A*-phase slots.

In a three-phase winding, the instantaneous polarity of the phase leads A_1, B_1, and C_1, must be such that any two of them are leading into the winding and the remaining one leads out. That is, if A_1 leads in and we make B_1 lead out, then C_1 must lead into the winding. Or, if A_1 and B_1 lead in, then C_1 leads out. If A_1 leads out then B_1 and C_1 must lead in. In this winding we will take the direction of flow such as to make the A_1 and C_1 leads go into the winding. Consequently, B_1 must lead out of the winding.

In a three-phase winding we will have twelve leads in all: a start and a finish for each phase, which accounts for six leads; and two reversing jumper leads (R_1, R_2, R_3, etc.) for each phase, which accounts for the other six. In a four- or six-pole machine it will be impossible to arrange the winding so as to prevent the crossing of these twelve leads; hence, the starting leads of the phases are placed as close together as conditions will permit. Since the A_1 lead is in slot *2*, we will place the C_1 lead as close to it as possible.

Based on the conclusion of the two preceding paragraphs we may start the *C* phase in slot *24*, or in slot *6*. If the phase is started in slot *24*, slot *23* will be the other slot for the *C* phase in the pole group that includes slots *1* and *2*. Likewise, if the *C* phase is started in slot *6*, slot *5* will be the other slot for the *C* phase in this pole group. Slots *3* and *4* are reserved for the *B* phase so as to keep the phases in order; that is, in the order *A*, *B*, *C*.

We will start the C_1 lead in slot *6*. Then R_3, according to *Rule 7*, will be a distance of $6+2-1=7$ slots, measured in a counter-clockwise direction, from slot *6* (that is, the slot to which the C_1 lead connects). Counting seven slots in a counter-clockwise direction from slot *6* we arrive at slot *23*, which is the location of the slot to which the R_3 lead connects. According to this same rule R_3 will connect to a bottom conductor. This is shown in Fig. 3. According to *Rule 8*, R_4 will be six slots, measured in a counter-clockwise direction, from slot *23*, that is, in slot *17*, as is shown in Fig. 4, and will be connected to a bottom conductor. According to *Rules 9* and *10*, the finishing lead C_2 will connect to a top conductor located in a slot that is six slots, measured in a counter-clockwise direction, from slot *6* (slot with which C_1 connects); that is, C_2 will fall in slot *24*. Fig. 4 shows the *C* phase drawn in complete.

We could have started the *C* phase in slot *24*, slot *12* or slot *18*, instead of slot *6*. Having selected slot *6* and because we have said that A_1 and B_1 must have the same instantaneous polarity, that is, both of them will lead into the winding, then slots *1*, *2*, *3*, *4*, *5* and *6* must all be of the same polarity and constitute one pole. If we had started the *C* phase in slot *24*, we would have made slots *23*, *24*, *1*, *2*, *3* and *4* the same polarity. Having decided that slots *1* to *6* inclusive form one pole, then it follows that slots *7* to *12* inclusive form another pole, slots *13* to *18* inclusive form the third pole and slots *19* to *24* form the fourth pole. We know the polarity of slots *1* to *6* because A_1 and C_1 must lead into the winding. The arrows in the slots in Figs. 1, 2 and 3 indicate the polarity of the slots in which we have wound the *A* and *C* phases. Since we know the slots in each pole group and that all slots in a pole group must be of the same polarity and also that adjacent poles must be of opposite polarity, it is easy to draw in the arrows indicating the polarity of each slot. This has been done in Fig. 4.

This diagram shows that the slots remaining for the *B* phase are slots *3*, *4*, *9*, *10*, *15*, *16*, *21* and *22*. The winding cannot be started in slots *3*, *4*, *13* or *14* because we have said that the B_1 lead must have the opposite polarity from A_1 and C_1 and hence, must lead out of the winding. This leaves slots *9*, *10*, *21* and *22*. Slots *9* and *21* can be disregarded because the second series of coils will fall in these slots. Slots *10* and *20* remain for the start of the *B* phase. The conclusion may be drawn from this that once we have selected the starting point of two phases, we have only two places left in which we can start the third phase in a four-pole machine, three places in a six-pole machine, and so forth.

We will choose slot *10* as the start of the *B* phase; hence the B_1 lead will connect to a conductor in slot *10*. Since we have started the A_1 and the C_1 lead in top conductors we will have to connect the B_1 lead to a top conductor. The first section of the *B* phase is shown in Fig. 5. According to *Rule 7*, R_5 will be a distance of $6+2-1=7$ slots, measured in a counter-clockwise direction, from slot *10* and will connect to a bottom conductor. Counting seven slots in a counter-clockwise direction from slot *10* we arrive at slot *3* which is the location of R_5. This is shown in Fig. 5. According to *Rule 8*, R_6 will be six slots, measured in a counter-clockwise direction, from slot *3*; that is, in slot *21* and will connect to a bottom conductor in that slot. This is shown in Fig. 6. According to *Rule 9*, B_2 will be located in a slot that is six slots, measured in a counter-clockwise direction, from slot *10*; that is, in slot *4*. According to *Rule*

These Rules for Laying Out Wave Windings Were Derived in the First Article of this Series

Rule 1—The number of coils in a series is equal to one-half the number of poles in the winding.

Rule 2—The number of series of coils equals the number of slots per pole per phase, which is equal to the number of slots divided by the number of poles and this result divided by the number of phases.

Rule 3—The number of sections equals twice the number of phases; that is, each phase will have two sections.

Rule 4—The number of coil groups is equal to the number of poles multiplied by the number of phases.

Rule 5—Between the starting and finishing leads of each section there will occur a number of short pitches equal to one less than the number of slots per pole per phase.

Rule 6—The reversing jumper lead (that is, R_1, R_2, R_3, R_4, R_5, etc.) and the finishing lead of the phases (that is, A_2, B_2, C_2) are on the left of their respective phase starting lead (that is, A_1, B_1, C_1), for a left-hand winding and on the right for a right-hand winding.

Rule 7—The first reversing jumper of a phase (that is, R_1 for A phase, R_3 for B phase, or R_5 for C phase) will be located in a slot that is a number of slots from the phase starting slot (A_1, B_1, or C_1, as the case may be) equal to the front pitch plus one less than the number of coils per group, measured in a counter-clockwise direction for a left-hand winding and measured in a clockwise direction for a right-hand winding. Also, if the starting lead (A_1, B_1, or C_1) goes to a top conductor, then the reversing jumper lead is connected to a bottom conductor.

Rule 8—The second reversing jumper lead for a given phase (R_2, R_4, or R_6) is connected to a bottom coil half or conductor when the first reversing jumper is connected to a bottom conductor and *vice versa*, and is spaced one front pitch measured in a counter-clockwise direction from the first reversing jumper for a left-hand winding and measured in a clockwise direction for a right-hand winding.

Rule 9—The finishing lead of a phase (A_2, B_2, or C_2), will connect to a conductor located in a slot that is one front pitch from the starting lead of that phase and is measured in a counter-clockwise direction for a left-hand winding and in a clockwise direction for a right-hand winding.

Rule 10—If the starting lead of a phase connects to a top conductor or coil half, then the finishing lead of that phase will connect to a top conductor, or *vice versa*.

10, B_2 will connect to the top conductor in that slot.

The ends of the three phases, that is, A_2, B_2 and C_2 are connected together to form a star jumper. The completed winding is shown in Fig. 6.

If we had decided to use the bottom coil halves in the slots for the line and star connections, the diagram would have to be numbered in the opposite direction to that shown in Fig. 6, that is, the numbers would run counter-clockwise, but the other rules would hold true.

In practice, it is not necessary to draw in all the coils together with all their front and rear connections as this would require considerable time for stators having a large number of slots and more than one coil per cell. All that is needed is a working diagram showing the slots to which the leads are connected, and which slot the short pitches and reversing jumpers fall in. In fact, some manufacturers only show one phase, or part of a phase, and give the rest in slot numbers.

Comparing Figs. 7 and 8 will give an idea of the amount of time that can be saved by not having to draw the complete diagram. If the total number of coils in a winding is large, the diagram can be simplified by just drawing the back connections of one series of coils for one phase only, as is shown in Fig. 8 in

Figs. 7 and 8—Considerable time and effort can be saved by making working diagrams instead of complete winding diagrams.

Fig. 7 shows the complete winding diagram for a two-phase, twenty-four-slot, two-layer winding. Fig. 8 is a working diagram for the same winding. In this diagram the information that the winder needs is given directly without the necessity of tracing through a maze of confusing lines.

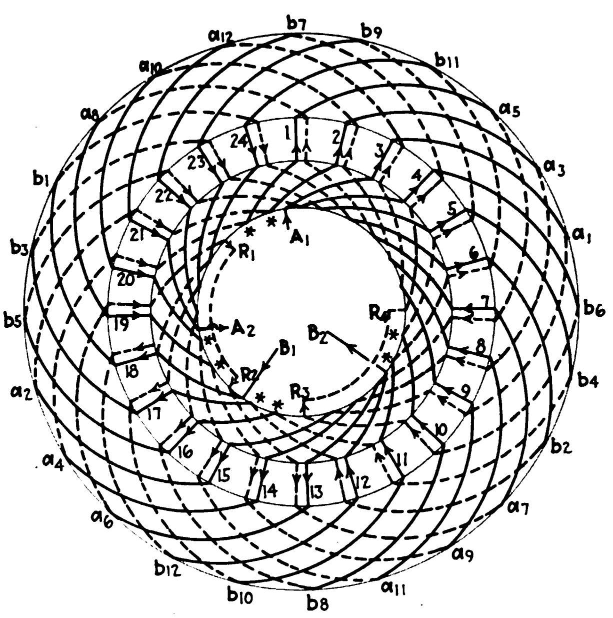
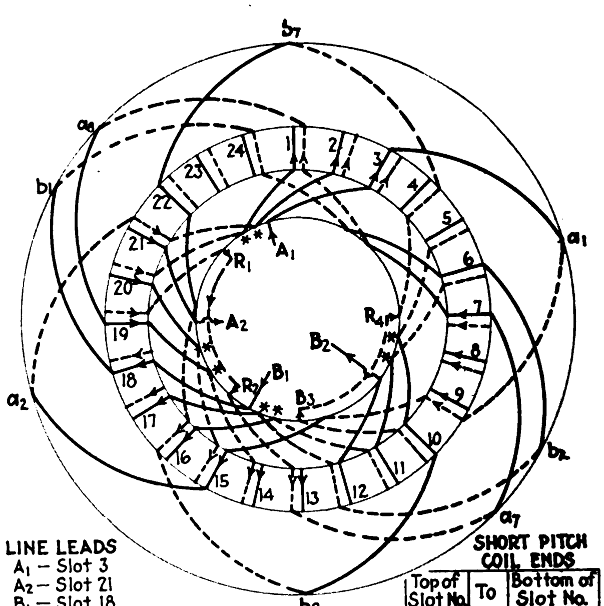


FIG. 7



LINE LEADS
A_1 – Slot 3
A_2 – Slot 21
B_1 – Slot 18
B_2 – Slot 12
Line leads connect only to top conductors

FIG. 8

REVERSING JUMPERS
R_1 – Slot 19
R_2 – Slot 13
R_3 – Slot 10
R_4 – Slot 4
Reversing jumpers connect only to bottom conductors

SHORT PITCH COIL ENDS

Top of Slot No.	To	Bottom of Slot No.
2	"	21
1	"	20
20	"	15
19	"	14
17	"	12
16	"	11
11	"	6
10	"	5

the back connections of coils $a1$ and $a2$. The reason that the back connections are not required on the diagram is that in the usual two-layer wave winding, the coil forms a complete unit; that is, the top and bottom halves of the coil are permanently joined together at the rear and thus the back pitch is permanently established. Consequently, all that need be shown is the front connection and the proper notation.

Figs. 9 to 12—Working diagrams for two- and three-phase motors showing series-star and series-delta connections for the latter type.

Figs. 9 and 10 are for two-phase motors. The former is for a six-pole, series winding having twenty-four coils and slots. The latter is for a four-pole, series winding having the same number of coils and slots. Fig. 11 is the working diagram for the three-phase, series-star, four-pole winding which is shown complete in Fig. 6. In Fig. 12 is shown the working diagram of a series-delta connection of the winding that is shown connected series-star in Fig. 11. The small sketches at the bottom of Fig. 12 show two ways of making the series-delta connection.

Fig. 7 gives the complete winding diagram for the two-phase, twenty-four coils and slots, winding which was worked out in the first article of this series on wave windings and is the same as Fig. 20 of that article. Fig. 8 gives the working diagram for this same winding. The tabulation at the lower right-hand corner gives the location of the short pitches. This table shows that the top conductor in slot 2 should con-

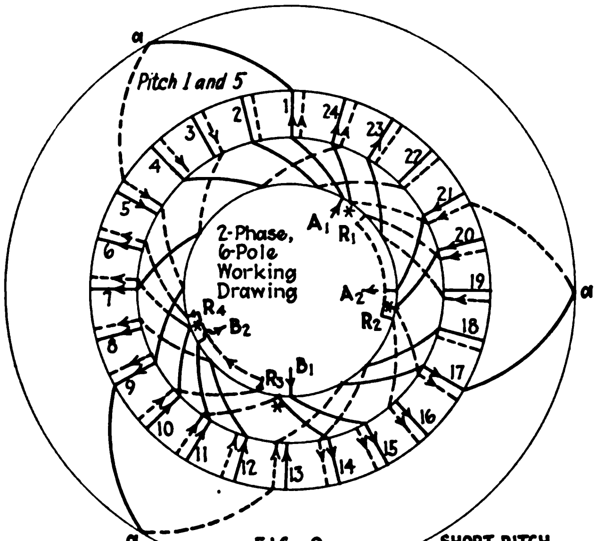


FIG. 9

LIVE LEADS
A_1 – Slot 1
A_2 – Slot 21
B_1 – Slot 15
B_2 – Slot 11
Line leads connect only to top conductors

REVERSING JUMPERS
R_1 – Slot 20
R_2 – Slot 16
R_3 – Slot 10
R_4 – Slot 6
Reversing jumpers connect only to bottom conductors

SHORT PITCH COIL ENDS

Top	To	Bottom
24	"	21
20	"	17
14	"	11
10	"	7

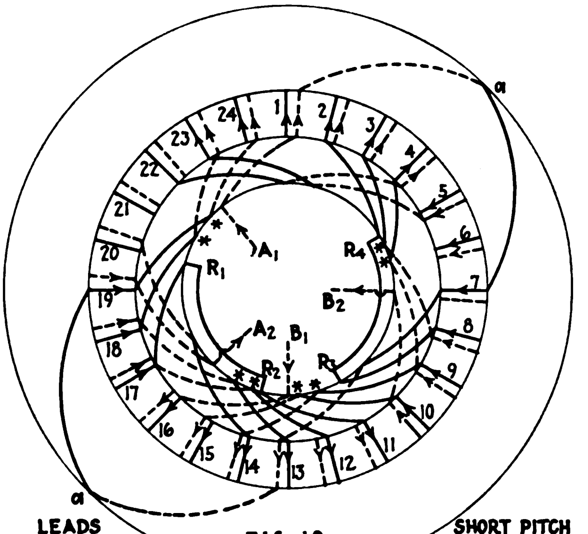


FIG. 10

LEADS
A_1 – Slot – 1
B_1 – " – 16
A_2 – " – 19
B_2 – " – 10
Line leads connect to bottom conductors

REVERSING JUMPERS
R_1 – Slot 17
R_2 – Slot 11
R_3 – Slot 8
R_4 – Slot 2
Reversing jumpers connect to top conductors

SHORT PITCH

Top	To	Bottom
3	"	8
4	"	9
9	"	14
10	"	15
12	"	17
13	"	18
18	"	23
19	"	24

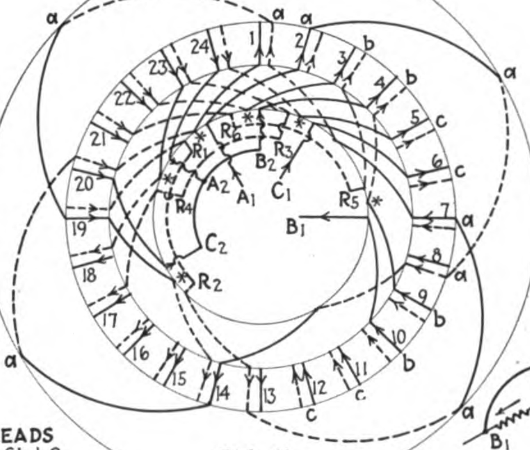


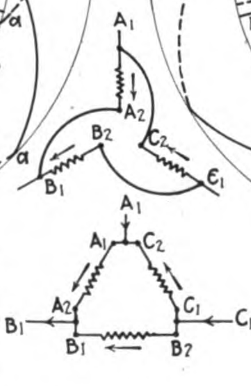
FIG. 11

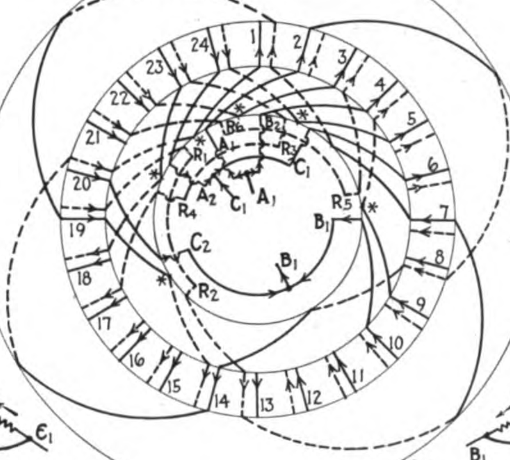
LEADS
A_1 – Slot 2
A_2 – Slot 24
B_1 – Slot 10
B_2 – Slot 4
C_1 – Slot 6
C_2 – Slot 20
Leads connect only to top conductors

REVERSING JUMPERS
R_1 – Slot 19
R_2 – Slot 13
R_3 – Slot 23
R_4 – Slot 17
R_5 – Slot 3
R_6 – Slot 21
Reversing jumpers connect only to bottom conductors

SHORT PITCH COIL ENDS *

Top	To	Bottom
19	"	14
23	"	18
1	"	20
3	"	22
5	"	24
9	"	4





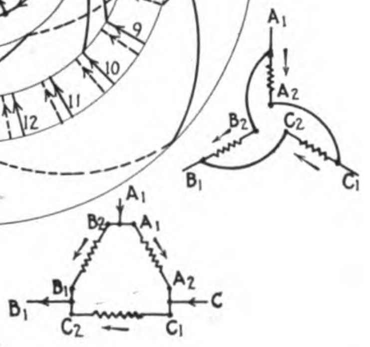


FIG. 12

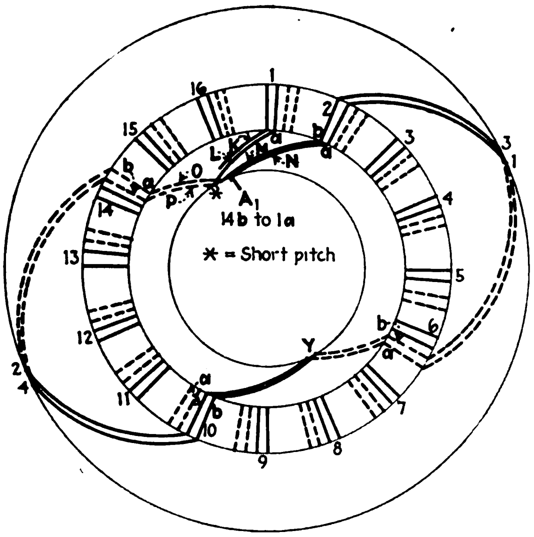


FIG. 13

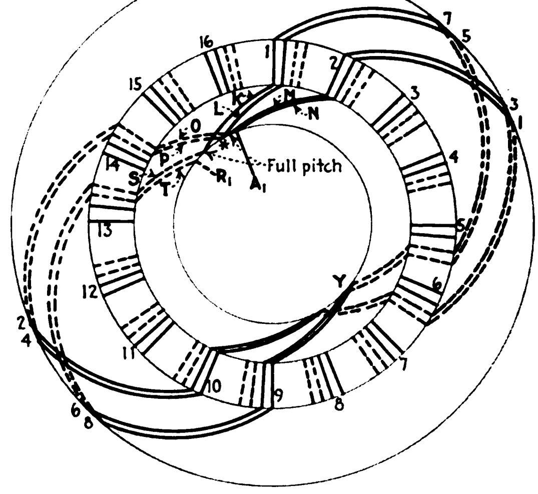


FIG. 14

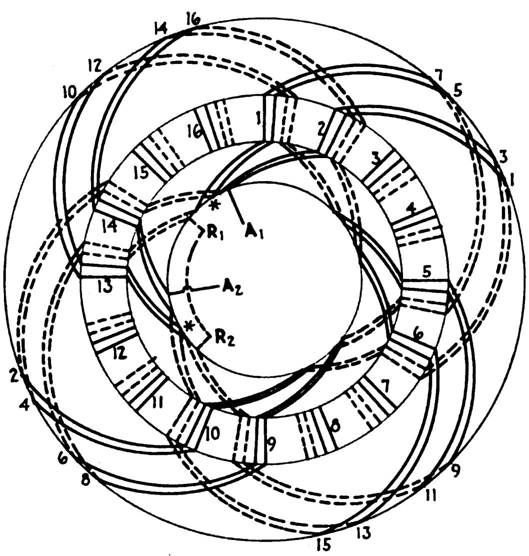
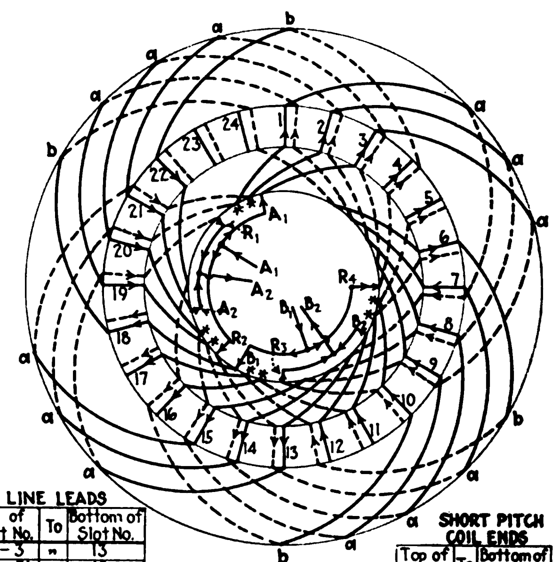


FIG. 15



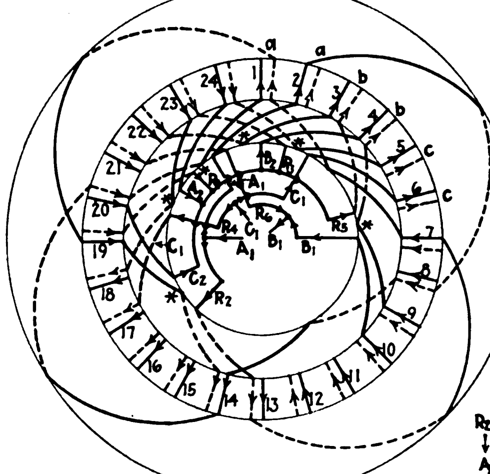
LINE LEADS

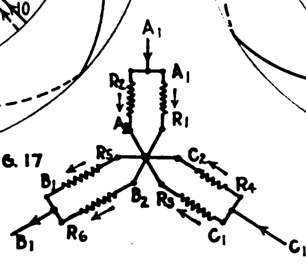
Top of Slot No.	To	Bottom of Slot No.
A1 – 3	"	13
A2 – 21	"	19
B1 – 18	"	4
B2 – 12	"	10

FIG. 16

SHORT PITCH COIL ENDS

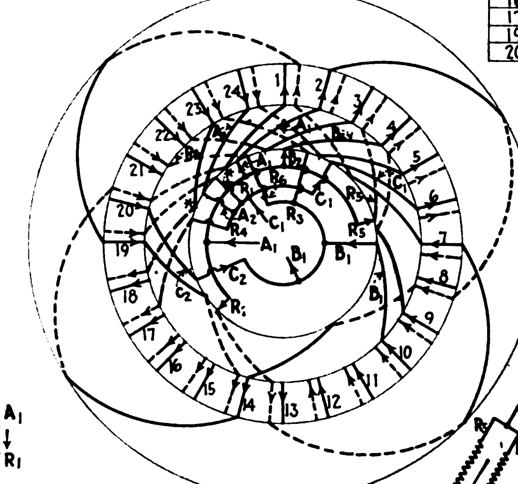
Top of Slot No.	To	Bottom of Slot No.
1	"	20
2	"	21
10	"	5
11	"	6
16	"	11
17	"	12
19	"	14
20	"	15

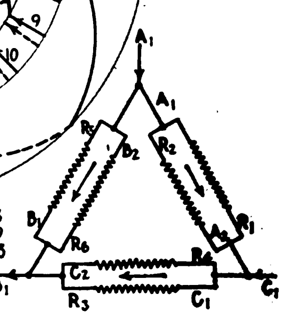




A-phase leads: Top 2; bottom 13
B-phase leads: Top 10; bottom 21
C-phase leads: Top 6; bottom 17
Top conductors 20, 24, 4 and bottom conductors 19, 23, 3 connect to star ring

FIG. 17





A-phase leads: Top 2-4; bottom 3-13
C-phase leads: Top 6-24; bottom 17-19
B-phase leads: Top 10-20; bottom 21-23

FIG. 18

Figs. 13 to 18—Diagrams showing different stages in making windings having four conductors per slot and how to make two-parallel star- and delta-connected windings.
Figs. 13 to 15 show three stages in making a two-phase, four-pole, sixteen-coils-and-slots winding having four conductors per slot. Fig. 13 shows how the first series of coils is connected to the second series. Fig. 14 shows the first section of one phase complete. Fig. 15 shows a complete phase. In Fig. 16 is shown the working diagram for a two-phase winding connected two-parallel. Fig. 17 shows a two-parallel, star-connected winding, while Fig. 18 is the same winding connected two-parallel delta.

nect to the bottom conductor in slot *21*; also the top conductor in slot *1* connects to the bottom conductor in slot *20*, and so on. The tabulation at the bottom of Fig. 8 gives the location of the reversing jumpers and the starting and finishing leads of each phase. The information given in Fig. 8 is of greater help to the winder than that given in Fig. 7 because in the former the winder would have to trace out the location of the short pitches whereas in the latter it is given to him directly and with less confusing lines.

Fig. 9 shows a working diagram together with all the necessary winding data for a six-pole, two-phase winding. This is a right-hand winding. Notice how the slots are numbered and that the rules which have been given before check this fact.

In Fig. 10 is shown a working diagram for a four-pole, two-phase, right-hand winding having the line leads connected to bottom conductors. Notice that the numbering of the slots in this case is the same as for a left-hand winding with line leads connected to top conductors.

In Fig. 11 is shown the working diagram for the three-phase, series-star winding which is shown complete in Fig. 6.

Up to the present we have considered windings with only one coil per cell, but in many cases there are two, three, and sometimes four coils per cell. These windings will give the winder more trouble than the single-coil job if he does not understand the method of picking up the series.

In Fig. 13 is shown the start of a two-phase, four-pole winding with sixteen slots and thirty-two coils, or two coils per cell. In any one slot there will be two top conductors or straps and two bottom conductors. The following rule must be observed:

Rule 11—In a left-hand winding in which the line leads are to be connected to top conductors, the line leads must connect to the top conductors on the right-hand side of the slot, while the reversing jumpers connect to bottom conductors on the left-hand side of the slot. When the line leads connect to bottom conductors, the bottom conductors on the left-hand side of the slot must be used and the reversing jumpers will connect to top conductors on the right-hand side of the slot. The opposite holds true for a right-hand winding; that is, with line leads connecting to top conductors, use left-hand top conductors, and the reversing jumpers will connect to right-hand bottom conductors. Also, if the line leads connect to bottom conductors, use right-hand bottom conductors for line leads and connect the reversing jumpers to left-hand top conductors.

Since the winding shown in Fig. 13 is a left-hand winding, according to the above rule, we will connect the line lead A_1 to the right-hand top conductor in slot *2* as shown. The rear end of this conductor is connected to the rear of the right-hand bottom conductor in slot *6*, for the back pitch is 1-and-5. The winding continues through top and bottom conductors alternately, the conductors marked *a* in slots *6*, *10* and *14* being used. This completes the first series of coils. The *a* conductor in slot *14* is connected to the start of the second series of coils. A full pitch in slots is used and the start is made on the *b* conductor in slot *2*. We then connect up the series of *b* conductors in the same slots used before until we reach the bottom of slot *14*. This completes two series of coils. Each slot has been passed through twice.

To continue the section, we connect the *b* conductor to the top conductor in slot *1*; that is, we drop one slot, making a short front pitch. From this we derive the following rule:

Rule 12—When there is more than one coil per cell, we pass completely around the winding as many times as there are conductors or coil sides per cell before we use the short (one slot less) front pitch.

Fig. 13 illustrates this rule. Fig. 14 shows one complete section drawn in. Notice that the first reversing jumper lead R_1 is connected to a bottom left-hand conductor. In Fig. 15, the second section of the *A* phase has been drawn. Notice that R_2 is also connected to a bottom left-hand conductor and that A_2 is connected to a top right-hand conductor. The remainder of the diagram can be readily worked out from the information that has been given.

In Fig. 12 is shown a series-delta connection for the series-star connected winding shown in Fig. 11. The two small sketches at the bottom of Fig. 12 show two ways of changing to the delta connection. In making a delta connection it will help any winder to consider the machine as being star connected. Then make a small open-star sketch as is shown at the bottom of Fig. 12. Then when making the delta connection, all confusion as to which pair of leads connects to any one line lead, is eliminated. The winding shown in Fig. 12 is connected as is shown in the lower right-hand schematic sketch in the same figure. In both the working diagram and the schematic sketch, the end of the *A* phase, A_2 is connected to the start C_1 of the *C* phase; that is, the top conductors in slots *24* and *6* go to one line lead. The end C_2 of the *C* phase is connected to the start, B_1 of the *B* phase; that is, the top conductors in slots *10* and *20* are connected together to the second line lead. The end, B_2, of the *B* phase is connected to the start, A_1, of the *A* phase; that is, the top conductors in slots *2* and *4* are connected to the third line lead.

This winding might also have been connected series-delta in the manner shown in the schematic sketch at the lower left-hand corner of Fig. 12. In this sketch the start, A_1, of the *A* phase is connected to the finish, C_2, of the *C* phase; that is, the top conductors in slots *2* and *20* are connected to one line lead. The start, C_1 of the *C* phase is connected to the end, B_2, of the *B* phase; that is, the top conductors in slots *4* and *6* are connected to the second line lead. The start, B_1, of the *B* phase is connected to the finish, A_2, of the *A* phase; that is, the top conductors in slots *10* and *24* are connected to the third line lead thus forming the closed delta. Hence, in constructing a delta-connected winding diagram it can be seen that the first part of the procedure is the same as for the star-connected diagram. Letter the start of each phase A_1, B_1, C_1 and the finish of each phase should be lettered A_2, B_2, C_2. Then after connecting the phases together as was shown in the schematic sketches of Fig. 12, the winding should be checked for polarity. As was stated before in this article, the instantaneous polarity of the phases should be such that any two phases will lead into the winding, while the remaining phase leads out. That is, if arrows are (*Continued on page 507*)

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT F. E GOODING A. J. WHITCOMB

Chicago, October, 1924

Who Is Responsible for Substation Failures?

IN THE interest of continuous service, periodical inspection of the industrial substation is a matter that deserves more attention than it usually gets. When energy is purchased, the responsibility for such work naturally falls upon the power supply company; but whether inspection of substations is done by outsiders or by the maintenance organization of an industrial works, there should be a thorough understanding of what such work involves on the part of the repair staff. The essential points of electrical inspection readily occur to anyone familiar with this class of equipment, but it is always helpful when the industrial maintenance organization "plays close" to the central station engineer in this regard.

It seems to be a fact that there are poor and good methods of doing inspection work, like taking oil samples, finding out how to store transformer oil, testing lightning arresters and other apparatus, and so on. In some localities it is now the practice to make a "fine-toothed comb" inspection of industrial substations once or twice a year, in addition to weekly or even daily superficial inspections associated with cleaning floors and grounds, and preventing the accumulation of dust and dirt on gauges, meters, relays and other equipment. The determination of the proper length of the period between inspections of various types should not rest on mere chance, but should be the result of a careful study of local conditions which co-ordinates the tasks of the electrical operating and maintenance forces with the primary object of preventing service failures and accidents.

Where an industrial plant has a number of such substations, adequate records are important and a leaf may well be borrowed from the central-station book in checking up procedure. The practice of making first-hand inspection records on stiff cards and later transferring these into a log book kept in a sectional binder has much to commend it. Data can be classified in this way for quick reference and if the log book carries a schedule of the inspection work due on each substation at different dates, it will help to insure promptness in covering the installations. Opinions differ as to the wisdom of including meter readings, records of the height of oil and operating history in the condition sheets; but without branching off into this detail, the point may be made again that a systematic effort to standardize and co-ordinate such work with provision for destroying unimportant records after a year or so of service deserves the attention of maintenance men.

What Goes on the Drive Side of the Coupling?

ANSWERING the big question, "What kind of apparatus shall we install at the motor side of the mill coupling?" L. A. Umansky said in a paper presented to the Association of Iron & Steel Electrical Engineers at their annual convention at Pittsburgh, Pa., "The primary purpose of any mill is to roll steel—the more of it the better. There is no use comparing costs of several systems of electric drive without testing their effect on the mill output; the most economical drive is not the one that has the lowest cost, but the one that costs the least per ton of steel rolled. The cost of electrical equipment is only a part of the cost of the whole mill; one is truly wise who pays more for a part in order that he may save on the whole."

This is also true in selecting the form of power drive for any industrial application. How often is it the case that a makeshift drive is installed in order that use may be made of an old spare motor of the wrong speed for the application, and thus save the cost of a new motor? How often do we place an open motor in a location that demands a mill-type motor just to save the added expense of the more rugged enclosed motor? How often does one put up with a large manual controller where an automatic controller would give more convenient and speedier operation? One might go on at great length in citing such examples.

The deciding point, however, in determining a drive installation is not its first cost, nor how easily it can be maintained but—is it the most economical from the standpoint of amount of product it will produce in a given time? As Mr. Umansky says, "It is far better to spend a little more time with pencil in hand, making a complete preliminary study of the subject, than to make a rash and possibly wrong decision and then pay for it in tons of steel that might have been rolled."

What Parts to Make and What Not to

IN THE discussion of maintenance procedure at a meeting of the Association of Iron and Steel Electrical Engineers in Pittsburgh last month, a superintendent of a large plant dropped a pearl of wisdom when he said, "Don't try to be a manufacturer." By this he meant that costs and facilities to produce parts should be carefully considered before deciding to make them for repair work on standard motors.

The case of making bearing metal was cited. On this he said that although it may be known what the analysis of the metal should show, it's quite another thing to put all the ingredients together and get what you expect. This is the business of manufacturers of bearing metals and since reliability of motor service is the thing the mill expects of its repair force, it is poor

policy to gamble with the quality of bearing metal by experimentation. Such procedure is usually expensive at best. In the matter of making coils, too, without good coil-winding and pulling equipment, the cost of coils for machines other than obsolete types is worthy of thoughtful study.

Again, the substitution of materials in repair work requires more than guessing. Before a change is made in insulating materials, varnish and the like used by the original manufacturer, much experience or consultation with other repair men should be the course followed, rather than depending upon experiments with this and that material, for at best a rewind job costs money and a failure at the wrong time may increase this cost to a point where expediency and a hurry-up job are more costly than a complete new motor.

While there are exceptions to all rules based upon experience and a thorough knowledge of the work being done, it is a good plan to confine repair work in a mill or factory to that class of repairs frequently required and go to the manufacturer for the special repairs and parts that call for particular manufacturing facilities or an expert knowledge of the requirements of their machines.

The Man Who Doesn't Make Mistakes Never Does Anything

SPEAKING before the Chicago Chapter of the Society of Industrial Engineers, Guy H. Rumpf, Works Manager of Joseph T. Ryerson and Son, Inc., expressed in the following words some viewpoints regarding the authority and responsibilities of foremen that are of interest both to executives and to those who work in the ranks:

> It is not necessary for the President, General Manager or Superintendent to understand the details of each particular machine or part of production. It is, however, essential that the foreman be capable of operating every machine and doing each piece of work in order that he may demonstrate to the men, whenever necessary, that his instructions can be carried out. Men have confidence in such a foreman and produce the best results.
>
> There should be one line of authority and this should come through the foreman. A foreman is held responsible for the production of his department and in order that he may produce the results desired he must have the necessary authority. * * *
>
> A superintendent or foreman should stand for his own mistakes. He should give instructions, expecting that they will be carried out and if they do not produce the proper results he should take the blame himself. Even though the foreman or superintendent may make mistakes, as long as he does not attempt to blame the workmen or someone else reporting to him, the men will retain their confidence and respect in their superior.

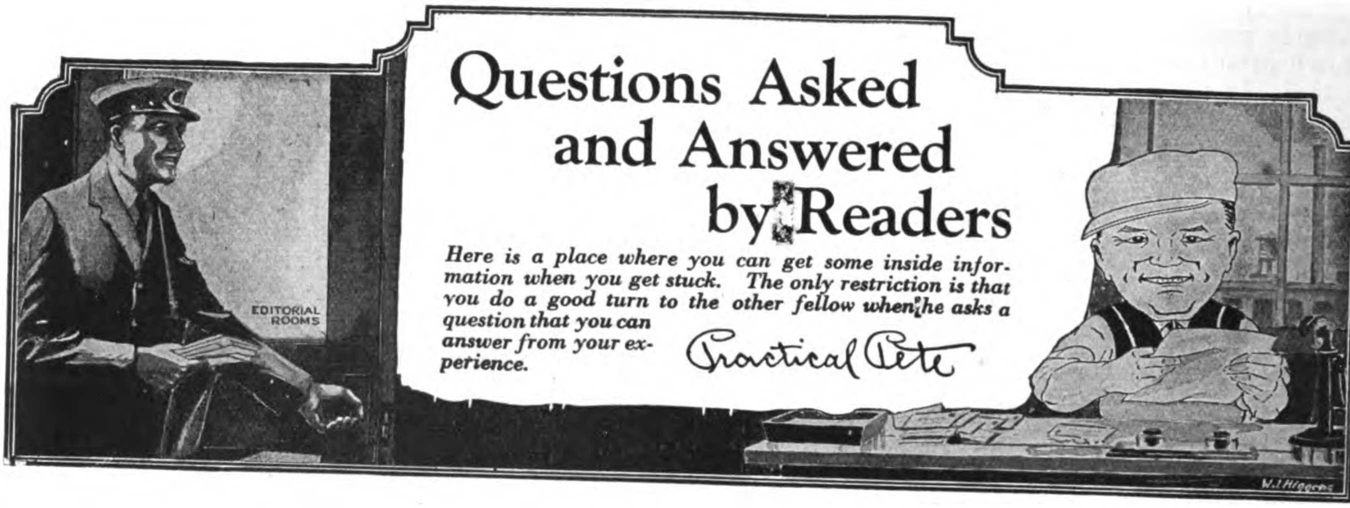
Important as these principles are in the conduct of the production departments, they are probably of even greater value in carrying on the work of the maintenance department. This department usually works under trying and unusual conditions and, particularly in emergencies, much must be left to the judgment and resourcefulness of the foremen and the individual workmen. Under such conditions, when decisions must be quickly made and carried out with perhaps only an imperfect knowledge of all of the factors that might influence the correctness of the decision, the chances of making mistakes are many. Nevertheless, it sometimes requires a good deal of moral courage on the part of foremen and of workmen to admit that a mistake has been made. Such an admission, frankly made, is one of the most effective means of showing your associates that you are the kind of man they like to work with, for the man who never makes a mistake never does much that is worth while imitating.

Job-Diaries on Maintenance Work

THE average industrial plant engineer concentrates so intently upon getting the physical side of his work done that he is often tempted to overlook the proper recording of its technical features after the time cards are completed and the vouchers initialed. Many highly competent maintenance men feel that their duty has been done when the basic cost data of a job are turned over to the accounting department. This is a natural attitude, but the trend of the times in maintenance work is towards its better organization and control from one year to another and this means capitalizing field and plant experience more thoroughly than ever before.

Any records that will keep a maintenance staff from duplicating preliminary work and investigations on new jobs from the drafting board up are essential to quick changes and repairs at the lowest possible cost. Under the stress of operation it is often necessary to push repair jobs through without slowing down the work for record preparation at the time; but after the job is completed, it is a great pity to forget it and to fail to put on paper for future use the more striking things about the task. We believe that there is a place in industry for what might be called maintenance-job diaries—books of loose-leaf type in which the details of interesting repair jobs are typed or written to provide information that will be useful in handling similar future jobs. On most maintenance work simple sketches of the methods of doing the work are required while the job is in hand. These are easily lost or destroyed if no effort is made to preserve them, particularly if they are rough "handy" drawings which do not have sufficient dignity of appearance to join the engineering department's "regular army" of tracings. Such sketches even fail to find lodgment in the engineer's personal notebook, and yet their correct filing with dimensions checked in the maintenance-job diary would save time, money and mental wear and tear if so indexed for subsequent work. Revised markings on these sketches also often indicate certain troubles that might be avoided in future work.

Along with these sketches, which could easily include wiring layouts, details of framing for portable motor test tables, sections of scaffolding and of other timbering used in supporting pipe runs, safety guard designs, etc., to mention just a few things worth recording, might go summarized cost data for particular jobs, names of men concerned and the time required to perform the work. There is scarcely any limit to the homely but intensely practical information that might find a berth in this kind of a reference book, which at very moderate expense could be transmitted to other engineers for criticism and improvement. There is no question that a lot of valuable repair job data now escapes from custody and is never recaptured after such work is done, and the maintenance-job diary would seem to be a suggestion worth trying in the interests of conserving future time, effort and expense.



Who Can Answer These?

Trouble Caused by Plugging Elevator Motor—Will some reader of INDUSTRIAL ENGINEER please give me some help on the following problems? (1) We have a 10-hp., 550-volt, three-phase elevator motor which is controlled by a Cutler-Hammer reversing switch. We are experiencing a good deal of trouble from blowing of fuses due to reversing the motor before the elevator comes to a full stop. This elevator has no regular operator and is used for freight service only. Has anyone had similar trouble and what is the best method of overcoming it? (2) Is it possible to wind a magnet that will lift from 10 to 25 lb. and can be operated on a 110-volt, sixty-cycle circuit? If so, please give me the winding data for 110 volts and also 550 volts.

Millbury, Mass. L. A. T.

* * * *

Removing Concrete Foundations by Blasting—We want to remove the foundation of a large engine and I should like to have the experience of other readers in removing foundations by explosives or in other ways. How can I keep down the concrete dust while drilling the foundation? If we blast the foundation how can I keep pieces from flying and damaging nearby machines? Will it be necessary to take the windows out? What explosive works best and how much should be used for a shot? I shall appreciate any suggestions you can give me.

Detroit, Mich. A. H.

* * * *

How Does the Lundell Motor Operate?—Can some reader of INDUSTRIAL ENGINEER give me a simple explanation of the theory of operation of the Lundell d.c. motor made by the Sprague Electric Co.? This motor has only one field coil (either series or shunt) which is placed in the frame in such a position that the armature rotates in the center of the coil. In other words, the field coil is wound around the armature.

I should like to know how and where the magnetic field poles are formed.

Philadelphia, Pa. C. F. S.

* * * *

Deterioration of Glass in Skylight—We have found serious deterioration of the glass in some skylights and wish to know if any reader has had a similar experience and can advise us what to do.

There are two machine rooms, one built in 1916 and the other in 1920, partly lighted by puttyless skylights glazed with ¼-in. wire glass. The glass in the first room shows no deterioration, beyond an occasional crack. In the skylights of the other room there are fine, interlacing cracks which in places expand into large patches. A skylight close to a relief valve, from which hot water sometimes drips, shows the most serious deterioration and in places has holes 2 in. to 3 in. in diameter. All of the lights are subjected to a temperature of 115-125 deg. F., from dryers below them, but none except the one mentioned above can be reached by anything except rain and snow. The skylights over the other machine room have been subjected for twice as long a time to identical conditions and are in practically perfect shape. Can anyone suggest the cause and a possible remedy for this condition?

New Haven, Conn. H. D. F.

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Priming Coat for Plaster and Brickwork—Will some reader of INDUSTRIAL ENGINEER please tell me what kind of sizing or priming coat should be applied when brickwork and plaster walls are being painted for the first time? We wish to paint the walls and ceilings of both office and shop and I understand that some preliminary treatment is necessary before the finishing coats of paint are applied.

Cleveland, Ohio. L. McC.

* * * *

Method of Checking Alignment of Lineshafting—We have two long, and several shorter lengths of lineshafting which I know is somewhat out of line, probably due to settling of the building. I shall appreciate it very much if someone will give me a simple method of lining up these shafts accurately in the hangers, so as to reduce friction in the hanger bearings.

Milwaukee, Wis. S. V. B.

Answers Received To Questions Asked

Trouble with Traveling Cranes—I am having trouble with two traveling cranes which run on the same track and are used for loading and unloading stone in a mill. One crane is rated at 20 tons and the other at 30 tons. Each crane has two slip-ring motors of about 20-hp. rating, which operate at 220 volts, sixty cycles and are controlled by General Electric starters. When both cranes are in operation the hookers on the ground get a shock every time they touch the chains which are used to carry the load. When either one of the cranes is idle, the men do not get a shock. I have tested out all circuits with a magneto and was not able to find any indications of trouble. I shall appreciate it very much if any of the readers of INDUSTRIAL ENGINEER can tell me how to find this trouble.

Bloomington, Ind. H. M.

In reply to H. M.'s inquiry in the August issue, it would seem that his cranes must be in a frame building, or the track is on a frame structure, and that there is a leak in the insulation of the motors sufficient, when both motors are running, to shock the men when they take hold of the hooks or chains, as this is the only path for the leaking current to get to the ground. I believe that if he will bond the rails and ground them well he will overcome this trouble.

This leak may be caused by the stator windings being oil-soaked sufficiently to make them conductive, although the leakage may not be sufficient to shock anyone when only one crane is running. Trouble from this cause may be cured by taking the motors apart, cleaning them thoroughly and baking the stator from 24 to 48 hr. in an oven at not less than 200 deg. F. and then applying a coat of a high-grade, air-drying varnish. I would advise a thorough inspection and cleaning of the motors by disassembling them. I have been able to overcome a great many troubles in motors by so doing.

I hope these suggestions will be of some help to H. M.

Chief Electrician,
Knoxville, Iron Co.,
Knoxville, Tenn. W. P. AMANNS.

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The conditions stated in H. M.'s question in the August issue, suggest the existence of high-resistance grounds on two legs, one or both of the grounds being on the motor side of the controller. Were the faults of the order of a short circuit, the magneto would have indicated the condition. Even low-resistance grounds would not blow fuses, assuming the crane construction, including the rails, to represent high resistance and the connection between the construction and the earth, on which the hookers stand, to be a poor one. The mere shocking of the hookers indicates that the current path, including his body, must have considerable resistance. As shocks are obtainable only when both controllers are on an operating notch, it might be enlightening to measure the insulation resistance of the motors and controllers to their frames. Charred insulation or accumulations of copper dust or carbon dust would admit current sufficient to cause a shock. If H. M. has no high voltage with which to test the break-down point of the insulations, the only alternative appears to be a thorough cleaning and overhauling accompanied by inspection. The removal of only one of the fault grounds would save the hookers further discomfort, but the removing of both is desirable because the existence of one invites the occurrence of another.

Brooklyn, N. Y. J. A. HORTON.

Methods of Repairing Wooden Floors—We have found that the wooden floors in the trucking aisles and particularly at corners where trucks are turned, wear more rapidly than the remainder of the floor. I would like to know the experience of some of the other readers of INDUSTRIAL ENGINEER in making repairs for these sections of the floors. Also, we would like to know whether our readers favor flooring laid parallel to the line of trucking, crossways, or on a diagonal.
Monmouth, Ill. J. H.

In answer to J. H.'s question in the July issue, wooden floors laid lengthwise to the line of travel are renewed more easily and cheaply than when laid either crosswise or diagonally, because in the former case every one of the boards will have been worn its full length; in the other two cases they are still good at the ends, and if they are to be salvaged, require more time for renewal.

Often a floor may be good enough outside of the trucking runway, and needs to be renewed only where it is very badly worn; the lengthwise arrangement makes it easier to do this.

Hard, thick maple flooring is the best and most economical in the end; of course, the length of time it will last depends upon the traffic. Rubber tires on all heavy trucks, such as electric tractors, etc., save wear on the flooring and the smooth surface saves the tires; together these make a neat and practical combination.
New Britain, Conn. H. S. RICH.

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Card System for Miscellaneous Power Drive Equipment—The only storage space we have for miscellaneous pulleys, shafting hangers and similar parts is some distance from the room which serves as the repair shop and headquarters of the maintenance department. As we now have no system of keeping track of this material one of the men must go and search through it whenever anything is needed. I should like to know if any reader has worked out a card system that we could use to tell what we have on hand.
Kansas City, Kan. H. L. G.

Referring to H. L. G.'s question in the June issue, I have been up against the same conditions myself, and have worked out a labor and time saving card system which may be of use to him.

I use cards 6 in. long by 5 in. wide, which are filed in a small box.

Cutting a piece ¾ in. wide and two-thirds the distance across the card leaves a margin above the rest of the card on which certain data can be kept. In the case of pulleys I put down the diameter, as this is usually the most important dimension. A pulley can be used even if the face is a little wide; also the bore can in most cases either be bushed or bored to fit the shaft, but the diameter can not very easily be changed.

For hangers I place the bore of the bearing in the margin.

Complete data for each pulley is entered on the body of the card. This data includes the condition, whether new or used, whether split-steel bushing or solid, from what machine taken off and any other facts that may be of use.

When a pulley is taken from stock note is also made on the card of its new location. Oftentimes a pulley on a very important machine will break or become useless through wear and there is no spare in stock. A glance through the card file may show one on another machine whose production is not so important and this pulley may be removed, saving the time of measuring different pulleys in trying to locate one that can be used.

Pulleys are stored on a rack made by nailing together two pieces of 2-in. by 6-in. timbers, and fastening them to a side wall. Pieces of 2-in. pipe, driven into holes bored at a slight angle into these timbers, support the pulleys. A wooden plug was driven into the ends of the pipes and sawed off flush. A piece of tin with a number stamped on it, was nailed to each plug, thus identifying the pipes.

When storing the pulleys, several can be placed on one pipe, depending on the weight and size. A separate card is used for each pulley or hanger, but all cards having pulleys or hangers listed on the same pipe have the pipe number in one corner of the card away from the rest of the data, so that it may be easily read.

My experience has proven that a card file on anything stored will soon pay for itself, and at present I am making one for pinions in storage.
Chief Electrician, N. H. CASE.
Wyckoff Drawn Steel Co.,
Ambridge, Pa.

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Replying to H. L. G. in the June issue, we use the card shown in the illustration for keeping a record of miscellaneous pulleys. These cards, which are standard 3-in. by 5-in. index cards, are made out by the head of the maintenance department and kept in his files. If there is on hand only one pulley of a particular size, a new card is made out when the pulley is sent to the stockroom. When the pulley is taken out of stock, the card is destroyed.

If there is more than one pulley of the same size on hand, the number shown on the card is altered each time a pulley is put into or removed from stock. I believe this card could be improved by adding the words Flat and Crown, one of which could be crossed out as needed.
Guilford, Me. DONALD MAXFIELD.

Record card for keeping track of the number and types of spare pulleys in stock.

MAKER	DODGE MFG. CO.
Style	"STANDARD" IRON SPLIT.
Diameter	29" Face 4" CROWN Bore 3 7/16"
Keyway	Setscrews 2 - 5/8"
No. on hand	6
Location	STOCKROOM.
Remarks	OLD LOOM DRIVE PULLEYS.

* * * *

Testing Large D.C. Generators for Short-Circuits—Will some one give me a good, practical method of testing for short circuits, large d.c. generators and motors, especially those having equalizers or cross connections? I have in mind machines of 1,000-hp. rating and over. In the various articles on testing which I have read, I have failed to find any mention of these connections and should like to know the procedure when testing out a machine which has them.
Ottawa, Canada. S. J.

In answer to S. J.'s question in the June issue, I use a lampbank and a millivoltmeter with a low reading scale, or an ammeter without the shunt and read only two bars at a time by touching both the line leads and the millivoltmeter leads to these two bars. Just enough lamps should be used in the bank to give a good reading, say, at least one-quarter of the scale. When employing this method of testing, you can disregard the equalizer connections.

When small armatures with equalizer connections are being tested, it is very important that the line leads be always placed on the equalizer connection. Otherwise, you will obtain different readings as you progress around the armature. Never try to test an armature with equalizer connections by a so-called buck or testing transformer, as the equalizers will act as a short circuit, giving in effect the closed secondary of a transformer and the armature may be damaged.
NICHOLAS J. WEISS.
West New York, N. J.

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From S. J.'s question in the June issue I assume that he is principally interested in testing for short circuits in the armatures of large d.c. generators, although it might be interpreted to include field tests.

The field windings, or rather the poles, may be tested by sending about 25 per cent of normal current through them, supplied from a steady source, and taking voltage readings across each field pole winding. A variable resistance may be found useful in keep-

ing the current at the same value throughout the test. Any marked difference in the voltage reading of one winding below the others may denote a partially short-circuited condition. The readings should be taken as rapidly as possible in order to avoid any error due to change of resistance from heating. A low-reading voltmeter should be employed and the field current kept as low as possible, or just sufficient to give a deflection of approximately one-half the instrument scale when the reading is taken across the field. It is very desirable that there be kept on hand data from the manufacturer giving the individual pole or total field resistance at some definite temperature, to which an actual test result may be corrected for comparison.

The true armature resistance of large d.c. machines with equalizer or equi-potential connections cannot be obtained so long as these connections are made to the winding. It is only possible to measure this resistance by disconnecting all the equalizer rings. It is imperative that there be on file comparison data from the manufacturer, giving the resistance of the winding as made in the shop at some definite temperature before the equalizer rings were connected. Probably the best way to test for short circuits in armature coils is by the "bar-to-bar" method. A low-voltage source of current, preferably a storage battery, is connected through a variable resistance of the carbon compression type, to adjacent bars and the drop of potential taken across these bars at equal values of current. This process is repeated until all bars have been tested. A reading which is very much lower than the others, or a zero reading, will indicate a short-circuited or partially short-circuited coil.

When testing for armature short circuits one of the greatest practical difficulties lies in obtaining reliable readings, owing to the very low resistance. It is impossible to obtain satisfactory results unless the voltmeter contacts are very firm and make a rigid, positive contact with the bars, and the use of contacts made of other material than the bars may cause an appreciable error. It is also difficult to obtain a readable voltmeter deflection at times, unless a very high capacity source of current is available. One of the largest manufacturing companies in this country has established the practice of rarely measuring the resistance of an armature after the latter has left the armature department, because of the difficulty of making such tests.

In routine repair shop work, short circuits in armatures can readily be detected by moving over the core another core built up of laminated iron and having a winding on it which is fed from an a.c. source. This test core is built up so as to have the same arc as the armature under test and can, therefore, be hung over it and close to it. Adjusting the test core and applying the a.c. current, the d.c. armature winding will act as the secondary of a transformer and any short circuits will be manifested by severe smoking. Obviously this procedure is more applicable to a shop where many armatures of the same size can be tested, but it can be used without much labor or expense under almost any conditions.

C. Otto von Dannenberg.
The J. G. White Engineering Corp.,
New York, N. Y.

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S. J. asks in the June issue for a method of testing large armatures for short circuits. One of the best methods to use is known as the bar-to-bar, or drop-of-potential test. In applying this test a steady current from a 110-volt line is sent through the armature from two opposite sides of the commutator. Readings of the potential drop between two adjacent commutator bars are taken on a millivoltmeter. A lampbank is inserted in the supply circuit and is adjusted until an easily-readable deflection of the millivoltmeter is obtained when its leads are touched to two adjoining bars, as shown in the illustration. In this, (C) is a fiber block holding the contact points, which should be spaced to rest on adjoining bars. Before starting the test it is advisable to take a reading at several different points, in order to get the average deflection, although in the case of good coils there is very little difference in their deflection.

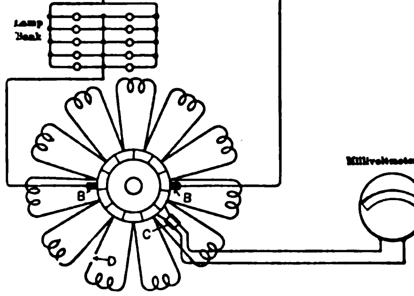

Diagram of connections for making bar-to-bar or drop-of-potential test on direct-current armatures.

The next step is to go all around the commutator, touching the contact points to each pair of bars in turn. If a short-circuited coil is encountered there will be little or no deflection of the millivoltmeter pointer, as there will be almost no drop through the coil.

This test can also be used to locate certain other defects in armature windings. For example, one type of crossed coil leads will be indicated by a deflection about twice as large as normal. Open-circuited coils or poorly-soldered leads are shown by a high reading.

Cedar Rapids, Iowa. John Griffin.

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In reply to S. J.'s question in the June issue, a rapid method of locating a short circuit in an armature without disconnecting any of the wires from the commutator is by the use of the bar-to-bar test. This test can be applied to any armatures with any style of connections, for there will be the same drop of potential between any two adjacent segments, no matter which scheme of connections is used.

In carrying out this test a steady current taken from a 110-volt circuit should be sent through the armature at opposite sides of the commutator. The brushes used should be just wide enough to cover one bar. A lampbank should be used in the supply circuit and so adjusted that a readable deflection is obtained when the two leads of a millivoltmeter are touched to adjoining commutator bars. The deflection of the millivoltmeter will depend on the difference of potential between the bars.

The contact points are touched to each pair of bars and the deflection of the millivoltmeter noted. If all of the coils are good practically the same deflection will be obtained all around the commutator. When the contact points are touched to the bars to which a short-circuited coil is connected there will be very little or no movement of the millivoltmeter needle, as there will be little or no drop through this coil.

Woodward, Okla. H. J. Acher.

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Construction of Pipe Rails and Guards—We have found it necessary to make some pipe rail guards to extend alongside some of our machines to prevent trucks from getting too close to them and also to provide a free aisle alongside the machines for the operators. As we wish to make these easily removable, I wonder if some of the readers of Industrial Engineer could offer any suggestions as to how these can be made sectional, the size of pipe to use, kind of fittings, construction of floor sockets, the span between supports, the most convenient length of sections and methods of connecting the sections.

Peoria, Ill. G. G. H.

Replying to G. G. H. in the July issue, I have used the following schemes in connection with removable guard rails, and have found them very satisfactory.

The first question to decide is the size of pipe to be used in making the rails. For ordinary purposes a rail made of 1½-in. pipe is strong and heavy enough; it makes a neat job and is not expensive. The length, height, number of bars and so on will depend on the conditions.

If the railing is to be set up on a wood floor a sufficient number of sockets should be made up from pieces of 2-in. pipe, assuming that the rail is made from 1½-in. pipe. These pieces should be cut 10 in. long and threaded at both ends. A pipe cap should be screwed on one end and a railing flange on the other. Holes should be cut in the floor at the points where the uprights of the railing will be erected. These holes should be accurately spaced with respect to the length of the rail, so that the latter can easily be set up and taken down. Also, it is desirable not to make the holes any larger than necessary, in order to give a firmer support for the sockets and lessen the danger of splitting the wood when the floor flanges are screwed down. Bolts, lag screws or wood screws may be used for this purpose.

If the railing is to be installed in concrete floors, a much neater job can be done as follows: Cut holes in the floor about 1 ft. deep and 3 in. or 4 in. in diameter. Pieces of pipe about 10 in. long should be placed in these holes, accurately spaced and lined up flush with the level of the floor and cemented in place. These sockets will be practically invisible when the railing is taken down.

When railing is to be removed in sections this can be arranged by making the sections shorter and leaving the desired space between them, or round, oak sliding bars may be used. If wood sliding bars are used they must be made to fit the pipe so as to slide in and out easily and all burrs on the inside of the pipe must be removed by filing, to prevent splintering of the bars.

Boston, Mass. F. J. H. KRAUSE.

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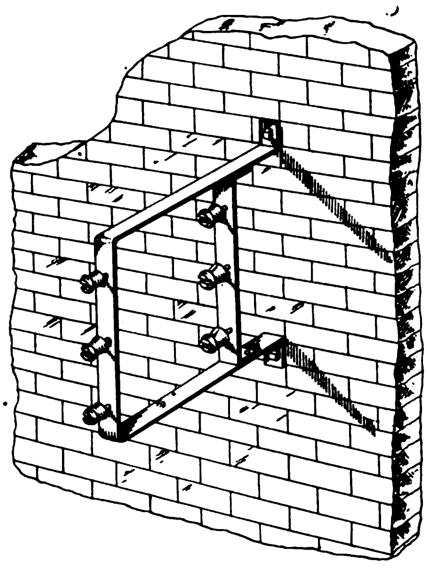
Will These Brackets Cause Trouble?—I am sending a sketch of an iron bracket which is to be used for supporting two sets of feeders for a three-phase, 550-volt system. Considering that the brackets are made entirely of iron, I should like to know if there would be



any inductive or other action if 20 or 25 of these brackets were used. If so, could it be eliminated by making the brackets of brass or copper? Will someone please advise me what to do?

Hastings-on-Hudson, N. Y. S. S.

In the July issue S. S. shows a sketch of an iron fixture which he contemplates using to support two sets of feeders. I can see no reason for not using this fixture, as feeders supported on the cross members will be in the same situation as if run through a short piece of large diameter conduit, and those on the outside of the fixture the same as if supported on a beam or girder, as is commonly done behind switchboards and in other station work.

Denver, Colo. JOHN E. HOLTMAN.

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Referring to the inquiry by S. S. in the July issue, the iron bracket shown may be considered as an iron conduit of large diameter. I know of one instance where single-phase current carried in conduit caused the latter to become so hot that you could not place your hand on it, and this overheating was remedied by carrying three-phase current in each conduit, instead of single-phase. Inasmuch as S. S. intends to carry three-phase energy on each bracket I am sure that he need not worry about any possible inductive effect which will cause heating. However, if his feeders are to carry heavy currents the bracket parts and insulator pins must be securely fastened together and the bracket have a good bearing and be tightly bolted to the wall; otherwise there may be produced a decided humming noise. If the above precautions are taken this humming will be minimized or entirely eliminated.

Further evidence that S. S. need not anticipate any undesirable effects from this type of construction lies in the fact that large feeders, carrying heavy currents, of the power companies' lines are carried in underground conduits and through tunnels on iron brackets and hangers which are more or less similar in design to the one he contemplates using.

Oakland, Calif. S. H. SAMUELS.

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Answering S. S. in the July issue, the metal in the brackets would cause no harmful effects on a 550-volt system, but if the insulators are exposed to the weather they should be mounted vertically, and not horizontally, as ice will form inside of the petticoat bells and break them open, thus allowing the conductors to ground on the sharp edges of the brackets. For out-of-door use the conductors must be at least 12 in. apart and the first one ought to be 1 ft. from the wall.

Galvanized, malleable-iron pins and bolts should be used, and mica insulators are the most durable, as both glass and porcelain will crack from temperature extremes and line strain. For indoor use, glass is good enough.

The brackets should be made of ½-in. by 2-in. iron, well bolted together, and either bolted or lagged to the walls by ⅝-in. bolts 5 in. or 6 in. long. If heavy lines are to be carried, bolts through the wall would be far safer. It must be recalled that during the winter the line must stand the strain of ice, snow and heavy winds, all of which tend to loosen the fastenings.

New Britain, Conn. H. S. RICH.

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In answer to the question by S. S. in the July issue, it is assumed from the sketch that one circuit is mounted on the outside and one on the inside of the bracket or, in other words, so that all three conductors of one circuit are inclosed by the strap-iron support.

There is no reason why the method of construction indicated will not be quite satisfactory, since the three wires of the one circuit are all located inside of the magnetic loop. Theoretically, there may possibly be some slight inductive effect due to the arrangement of the conductors in a horizontal plane, but even with unbalanced currents in the different conductors this effect will be small if only twenty or twenty-five brackets are installed and the circuit is not of any considerable length.

The writer has in mind a specific instance in his experience where it was necessary to carry a three-phase circuit having a maximum current of 1,100 amp. at 60 cycles through a large plate girder. This was done by cutting through the girder a triangular hole of sufficient size to carry the conductors, which were placed in insulating tubes. Absolutely no heating or other trouble has developed after more than five years of operation.

There have been specific cases where heating has developed but these are usually limited to instances where very heavy currents are carried, as in electric furnace work.

In any event it would be unnecessary to make the brackets entirely of brass or copper. By simply breaking the magnetic circuit and inserting a copper connecting piece, thereby placing an air gap in it, there would be practically no reason for any noticeable inductive effect. C. OTTO VON DANNENBERG.

The J. G. White Engineering Corp., New York, N. Y.

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In reply to S. S.'s question in the July issue, we are using practically the same method of carrying three three-phase circuits on an industrial job. In this case No. 4 conductors are used and no trouble has been experienced in the three years this installation has been in service. I should say, therefore, that S. S. would be perfectly safe in using the type of bracket shown with his question.

Woodward, Okla. H. J. ACHEE.

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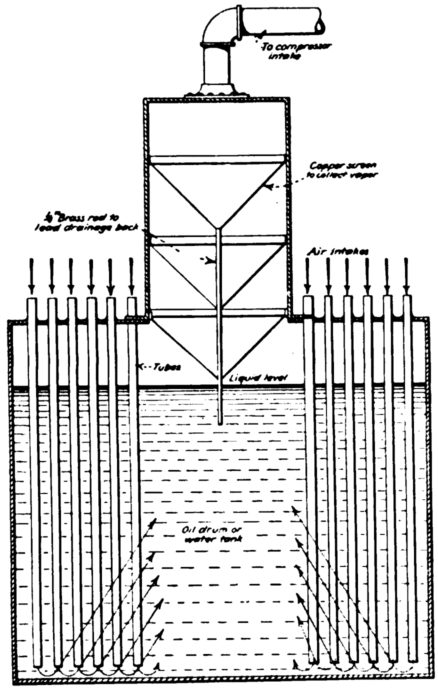
Air Filter for Intake of Air Compressor—I should like to get a little information from someone who may be inclined to lend a helping hand. The plant where I am employed has installed two feather-valve air compressors. These compressors are subjected to coal dust, coal smoke and sand and we are having trouble with the valves. After cleaning them they operate satisfactorily for about 24 hours, and then begin to hang and stick.

Will someone please give me complete details of a suitable screen or air filter that I could make and use on the intake of these compressors?

Norfolk, Va. W. B. E.

With reference to W. B. E.'s question in a late issue, I would suggest that he procure an old, steel oil or water tank of about 75-bbl. capacity and weld in place a large number of tubes, as shown in the illustration. These tubes may be suitable lengths of pipe and



Suggested method of filtering intake air for air compressor by passing it through water or oil.

should extend to within 2 or 3 in. of the bottom of the tank, which should be partly filled with water, or oil if it will be exposed to low temperatures. The upper end of the tubes should, of course, be open so that they will serve to conduct the incoming air through the liquid in the tank and thus free it from dust and other foreign matter. Without knowing the size of the compressor in question, it is not possible to give the size and number of tubes, but I do not believe that they should be larger than 1 in. in diameter. W. B. E. should put in enough tubes to make their aggregate area somewhat larger than the area of the compressor intake. The more tubes that can be conveniently placed in the tank the better, as the resistance to the passage of the air will be reduced and less vapor will be carried over.

It would also be necessary or advisable to mount on top of the tank, over the manhole, a dome which should serve as the outlet for the filtered air and be connected to the air intake of the compressor. This dome should be built of ¼-in. boiler plate and made air tight. It should contain fine wire screen which would serve to stop vapor and liquid particles from being drawn over into the compressor.

I believe a device of this sort would solve W. B. E.'s problem, providing that he constructs one which will be large enough to supply the compressors without too much liquid being drawn over. In any event, I hope that this suggestion will be of some help to him.

Marietta, Ohio. E. L. WAY.

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Moisture-Proofing Treatment For Motors in Pulp Mills—I wish some of the readers of INDUSTRIAL ENGINEER would tell me what method or treatment they use for keeping moisture out of the windings of motors and other electrical equipment which is located in very damp places, particularly in paper pulp mills. I shall be very grateful for any information you can give me.

Temiskaming, Que., Can. J. H. S.

Answering J. H. S. in the July issue, to moisture-proof motors, either d.c. or a.c. types, first disassemble to such an extent that all windings are within reach; then clean out all dust, etc., preferably with dry compressed air. Put all parts carrying windings in a very warm place, as in an oven, or on a boiler top, and thoroughly dry out all traces of moisture. Then coat the fields or the stator windings with P. & B. or some other good standard armature varnish, being sure to get it into all crevices. If either the armature or the rotor cannot be dipped bodily, spray or brush the varnish on well and in between all leads.

All windings should then again be subjected to a mild heat for at least 24 hr. One thorough coating with good quality varnish generally is sufficient, but for more certain protection against moisture two coats are better.

The chief consideration is that all windings must be thoroughly coated, and the varnish should be fairly dry before the motor is put to work.

Starting compensators can be cleaned and heated without much trouble, and then well coated with varnish, especially at coil windings and terminals. Shellac does not answer the purpose as well as do especially-prepared armature varnishes. If the latter are too thick, do not thin down too much, as certain parts, like tape windings, mica insulation under the windings, etc., may be loosened by the softening effect of the thinner.

Windings which are well varnished before being put to work and then treated again similarly after a few weeks, or whenever overhauling is done, will be well-night moistureproof.

Induction motors so treated have been operated out-of-doors on coal hoists and cranes the year 'round, with no breakdowns.

New Britain, Conn. H. S. RICH.

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In answer to the question asked by J. H. S. in the July issue, there is no way of keeping water and moisture out of most of the motors because the surrounding air is saturated with moisture. Most of the trouble is caused by water being splashed on the motors when cleaning up. Machine room bosses and superintendents are always willing to co-operate with the electrical department in trying to keep the motors as dry as possible, but the help that does the cleaning usually changes frequently. About the time that you think the cleaning crew is educated to the dangers of getting water on electrical equipment you come in some morning and find a bright young fellow washing spider webs off the ceiling over the motors. He thinks he is doing you a favor by washing off the dust. So it is a question of how to make motor windings resist water and moisture.

After a thorough investigation and study of ways of treating motor windings the following method was adopted. It has been found very satisfactory, as I have not rewound a single motor in the six years since I started this treatment.

When a motor is brought in to be rewound, the type of connection, coil pitch, size of wire and other data are taken when the stator is stripped. In particular we note whether the wires fit very tightly or loosely in the slots, to see if the thickness of the slot insulation can be increased. Whenever possible the coils are made of double-cotton-covered, enameled magnet wire. The thickness of the slot insulation depends on the size of the motors and the amount of room in the slots. Generally one cell of 0.012-in. or 0.016-in. fishpaper is put in the slot next to the iron and reaches up to where the bottom of the wedge will be. One cell of 0.015-in. empire cloth, of the same size, comes next and another cell of 0.007 or 0.009-in. fishpaper is placed inside of the empire cloth cell and extends about ¾ in. above the top of the slots to protect the wires when they are placed in the slot. Another fishpaper cell of the same thickness is placed between the top and bottom sides of the coils. The coils are taped with one layer of 0.010-in. cotton tape, ½ in. to 1 in wide, depending on the size of the coils, lapped half-way. Two thicknesses of 0.015-in. empire cloth are placed between phase coils.

When the motor is completely rewound it is given an insulation test of 1,100 volts to ground, with ten 110-volt lamps in series, for about one minute. It is then assembled and run for about an hour or so to make sure that the connections are right and that there are no short-circuited coils. Following this, the motor is taken apart and the stator placed in the oven for four or five hours at a temperature of about 75 deg. C. This heating helps the varnish to penetrate the coils. If they are cold the varnish will be chilled and tend to thicken, thus preventing it from reaching all parts of the coils and sealing up portions of the slots that the coils do not fill up.

By means of a chain block the stator is then lowered upside down into a tank of black, elastic baking varnish, made by the Sterling Varnish Co., until all of the coils are covered. The stator is allowed to remain in the varnish for about two hours, or until all bubbling has ceased. This insures thorough penetration of the coils. The stator is then raised out of the varnish and left hanging until it stops dripping. During this period I keep the varnish tank covered with heavy paper or canvas, with a slot in it large enough to let the chain go through, in order to keep dirt out. Keeping the tank covered also helps to prevent evaporation of the thinner and facilitates draining of the coils, as the varnish is not chilled and thickened before it has a chance to drip off. The stator is then baked at a temperature of about 100 deg. C. for twelve to fifteen hours. We dip and bake stators three times and afterwards give them a brush coat of black, quick air-drying paint.

The treatment described above applies to stators where the slots are semi-closed and the coils taped after they are in place. I have so few failures in the larger sizes of motors, in which the coils are made of square wire and taped before winding, that I do not attempt to make the coils. They are purchased from the manufacturer and after the stator is wound it is dipped and baked twice, in order to fill up the slots and insulate the end connections.

MARIN PHILLIPS.
Electrical Superintendent,
Interlake Pulp and Paper Co.,
Appleton, Wis.

* * * *

Connecting Extension Bell to Telephone—I shall appreciate it very much if readers will give me some information on the following problem. In our engine room we have a telephone which operates from the city system, through our own switchboard. When the engines are running it is impossible to hear the bell ring unless some one is standing close by the telephone. I wish, therefore, to install a large alarm or extension bell. How should this be connected? What voltage is used to ring the telephone bell? What voltage and type of bell should I use? Is it necessary to use a relay for this bell; if so, what type is preferable? Please give me a wiring diagram showing how this bell should be connected.

Chicago, Ill. W. A. B.

In answer to W. A. B. in the September issue, I believe he will find that the telephone companies do not permit subscribers to connect extension bells or any other devices to their lines or to any lines connecting with the companies' lines. Upon application and the payment of a small installation charge, the telephone companies will, however, put in any desired size of extension bell.

Walkerville, Ont., Can. R. B. TURNER.

Building Maintenance and Plant Safety

The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Reducing Fire Hazards from Dipping Tanks

PRACTICALLY every modern factory employs some sort of dipping, quenching, or spraying operation which uses inflammable liquids and thereby creates a special fire hazard.

The automobile industry furnishes an excellent example of the dipping process. Here are found large dipping tanks in connection with especially-designed mechanical conveyor systems and baking ovens.

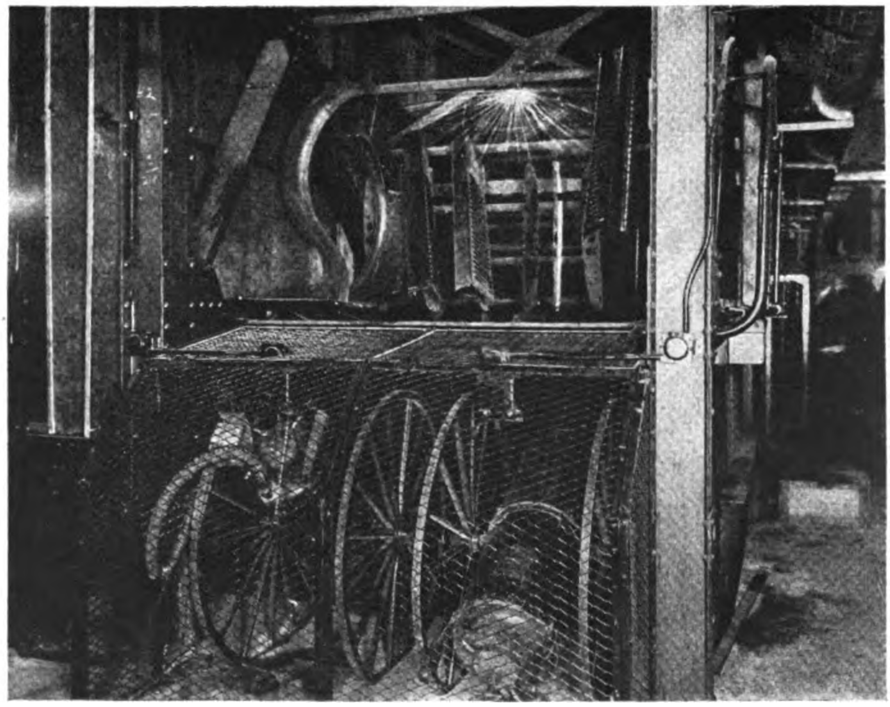
Closely allied to the dipping tank as a fire hazard is the quenching tank, for hardening and tempering the many varieties of alloyed steel needed in the manufacture of modern machine parts. Most of these processes involve the use of tanks holding highly inflammable compounds. The more inflammable mixtures used contain naphtha, benzine, gasoline, and benzol. Of a less hazardous nature, but at the same time extremely dangerous, are mixtures containing turpentine, kerosene, linseed oil, heated asphaltum, paraffine, and quenching oil.

The Danger.—Dip tanks with their drain boards, quenching tanks, saturating tanks and the like, are a potential source of extraordinary fire danger which no plant manager can afford to underestimate. An effort to speed up production, an over-heated oven, a defect in electrical equipment, an open flame carelessly brought within the zone of the highly inflammable vapor from the dip tank, may render useless all the arduous efforts of the plant's designing and operating engineers to maintain continuous production. Once started, a fire will spread if it is not controlled by adequate fire fighting equipment of a type suitable for the particular risk.

Need for Fire Prevention.—The need for making every reasonable effort to prevent fires is self-evident, but unfortunately it is often overlooked. Fire prevention deserves very serious consideration in every phase of manufacturing, whether it be design, construction, operation, or maintenance. Practically every industrial fire furnishes lessons in fire prevention which can be applied to hundreds of industries with considerable advantage. There are certain special precautions which will help to prevent fires in and around dip tanks, quenching tanks and so on.

Static Electricity.—One of the most common causes of fires, and one of the most difficult yet important to guard against, is static electricity. This factor has lately been the subject of considerable discussion among fire protection engineers who realize its significance, especially under conditions in which inflammable and explosive vapors are present. The charge of static electricity, which is such a potential danger, arises from many causes, the principal one being friction between two bodies one of which is a poor conductor of electricity and not properly grounded.

An excellent example is found in connection with the use of leather belting, where it is almost impossible to eliminate the accumulation of static



A new method of protecting paint and japan dipping hazards in an automobile factory.

It has always been difficult to protect an open dipping tank from fire hazards. This difficulty has been increased by the use of conveyors for dipping and drying japan, paint, enamel and other similar work. This dipping tank is protected by two 40 gal. Foamite engines which are connected to a special actuator above the tank. This actuator is connected by a hollow tube to a compensator. A rise in temperature of over 15 deg. per min. increases the pressure in the actuator and transmits it to the release which tips the engine and discharges the Foamite, which is a frothy mixture, both above the tank and on the side (not shown here) to smother out the fire.

charges caused by friction between belts and pulleys. For this reason, it is highly important to remove all leather belting from close proximity to inflammable liquids, as the existence of the static charge carries with it the danger of an electric spark jumping from the belt to another body, such as a dip tank, having a different electric potential. To reduce the danger of static to a minimum, all shafting should be definitely grounded at either end. The principle of grounding should be carried out in the case of all apparatus where static charges are likely to be generated. An effective method of grounding is to bind or solder to the apparatus a copper wire which in turn is securely soldered to the water piping system in the factory. For desirable strength, the copper wire should not be smaller than No. 6 B. & S. gage.

Mixing aluminum bronze with belt dressing and applying it to the inside and outside belt surfaces will form a fairly good conductor between the grounded pulleys.

Ventilation.— Adequate ventilation is very important in all risks where inflammable vapors are involved. As these vapors are usually heavier than air and therefore tend to settle to the floor, the ventilating system must be designed with intakes near the floor level. In processes which give off warm vapors, the ventilating system should make provision for the rising of these vapors to the ceiling of the room. Natural ventilation is always to be preferred to artificial where it can be efficiently applied.

Construction.— Dip tanks should be isolated in separate rooms of incombustible construction. Where the manufacturing operation requires their location in the same rooms with baking ovens or similar equipment, special precaution should be taken to reduce the fire danger to a minimum.

The storage of reserve supplies of dipping liquid should be located at a safe place outside of the room containing the dip tanks. Draw-off connections should be constructed which can operate automatically to remove the contents of the dip tanks when not in use, or at time of fire.

Electrical Equipment.—All electrical equipment should be strictly in accordance with the National Electrical Code and approved by a proper authority. This applies not only to the original installation, but to later extensions as well. Cut-outs, switches, motors, and similar equipment should not be installed in the same room with the dip tanks. Where this is not practicable, special safeguards should be provided, such as spark-proof motors and the enclosure of cut-outs, switches, and similar equipment, in incombustible cabinets. All wiring should be enclosed in steel conduits, and pendant lamps should be provided with approved flexible cord, free from contact with pipe, machinery, and other fixtures. Lamps of portable type should be equipped with approved reinforced cord to insure protection against abrasion. Heavy guards should be provided for such lamps.

Spray Booths.—The application of paint, varnish, lacquer, and similar coatings by spraying with an air brush or direct pressure has come into extensive use, and with it a rather bad fire record. This process should be conducted only in a well-ventilated and protected spray booth. Most fires in spray booths result from fans and motors used for ventilating the booth, from lamps and other electric devices capable of producing sparks, and from the cleaning of the booths with highly inflammable solvents.

[This discussion of the hazards of dipping and suggestions on overcoming them, which should be known by every industrial man responsible for the conditions surrounding dipping hazards, is taken from recent literature issued by the Foamite-Childs Corp., Utica, N. Y.]

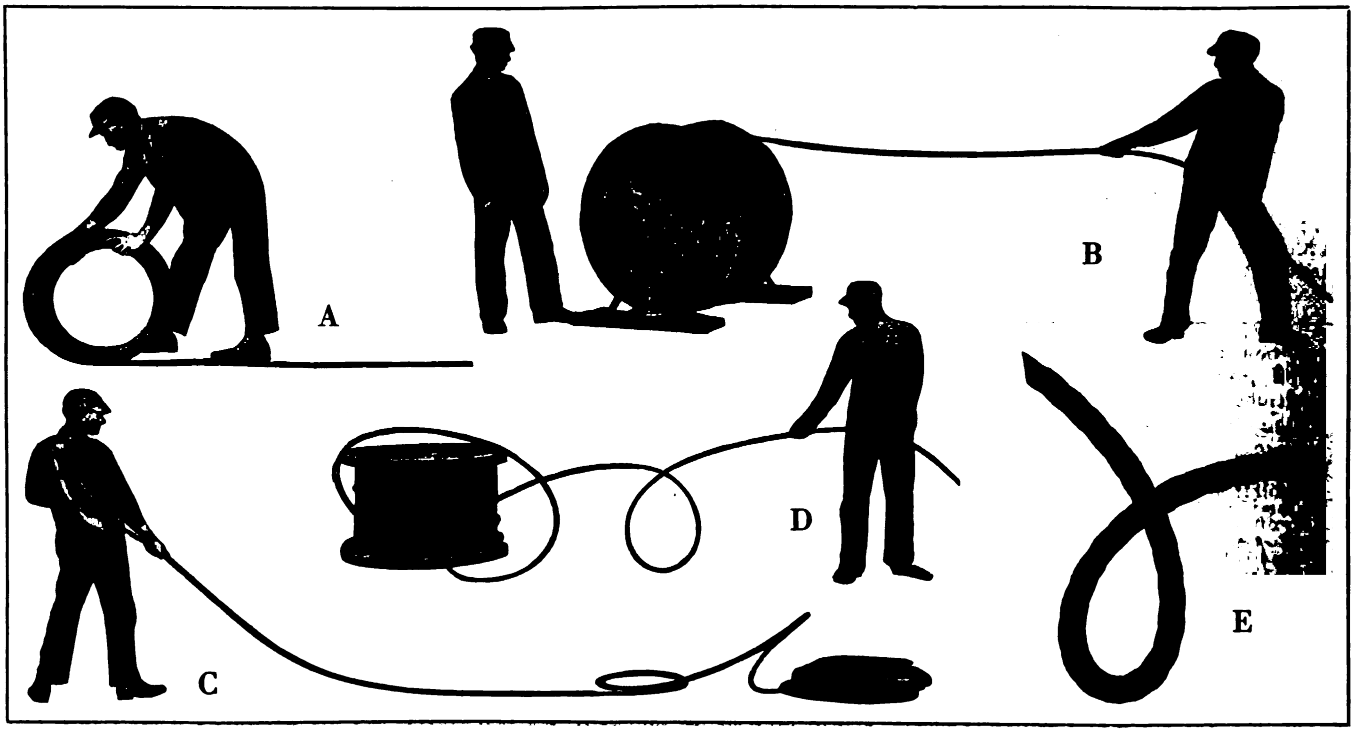
Avoiding Kinks in Unreeling and Uncoiling Wire Rope

INDUSTRIAL men frequently have occasion to remove wire rope from a reel or coil. When a wire rope receives a kink, as shown at (E) in the accompanying illustration, it is sure to have serious results upon the life and strength of the rope if actual breakage does not occur. The accompanying illustrations show the method of uncoiling and unreeling wire rope recommended by A. Leschen & Sons Rope Company, St. Louis, Mo.

When rope is received on a reel, the best way to remove it is to jack the reel up, as shown in (B), and uncoil it straight away. Care must be exercised to see that the reel does not turn too rapidly and loosen a coil or two which may slip over the end and result in a kink, if great care is not taken. When rope is received in a coil, it should be handled as shown in (A); that is, roll it on the ground like a wheel or hoop. It should always be remembered that wire rope must not be coiled or uncoiled like hemp rope. When coiling a wire rope, if it should for any reason become looped, as shown in (D), the loop should be drawn out at once for if a load is put on the rope in this condition damage is bound to occur. In case a wire rope is to be coiled after being used, reverse the above operation. Illustrations (C) and (D) show what is bound to occur when a wire rope is carelessly unwound by laying the coil or reel on the ground.

These five illustrations show how and how not to unreel or uncoil wire rope.

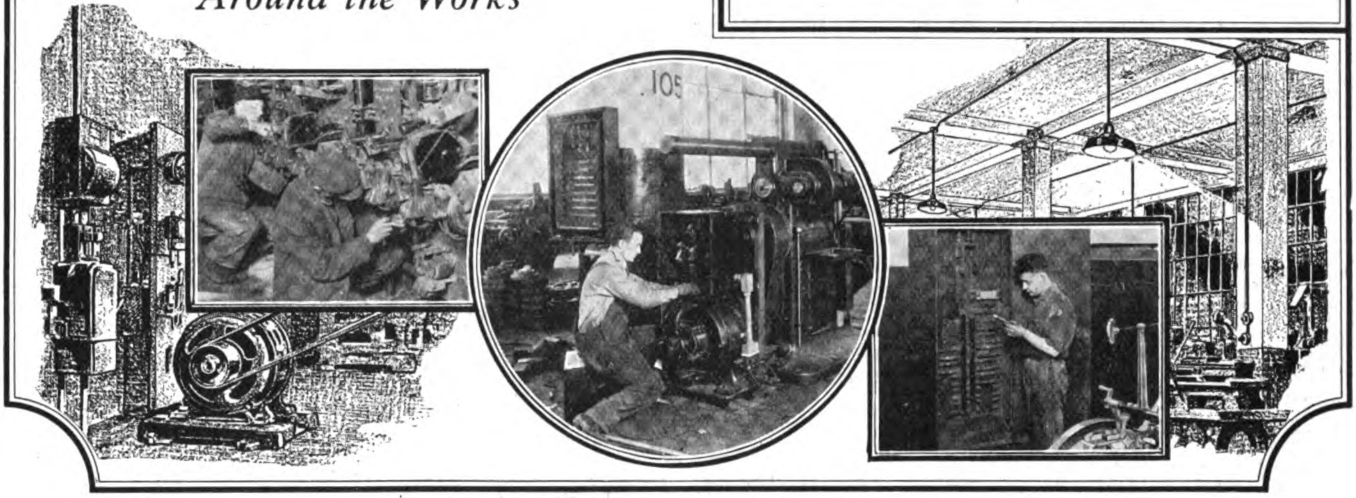
If a load or pull is applied to a wire rope with a kink in it, as shown in *E*, damage is almost sure to occur, with perhaps breakage as a result. Illustrations *A* and *B* show the right way, while *C* and *D* show methods which should never be used in the handling of a wire rope. In case it is desired to roll up the wire rope, operations *A* and *B* should be reversed.



Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



How Over-Lubrication and Dust Stopped a Motor

THE big surface grinder in the lower shop stopped suddenly one day. The group that gathered about the operator quickly diagnosed the trouble as "hot box" and in the motor "most probably, 'cause she's warm." The machinist who was sent to fix it up started on the hot-box theory and ran down one bearing after another until he had found all free except in the motor.

He couldn't turn the rotor and forthwith stripped the driving chain and sprocket off and removed the head of the motor on that side. It came off easily and, as the rotor did not pull out, he took off the other head. This, to his surprise, also came off easily. It was an induction motor and the rotor was stuck within the stator.

Following the conventional line of thought, a test was made to see if the bearings had worn so that the rotor had dragged on the laminations and thus gathered up particles that had finally enmeshed it. Such was not the case and the trouble was proven to be the accumulation of dirt and dust which, because of too frequent oiling, had formed a pasty substance that had finally gripped the rotor so that it had stopped the machine.

The cleaning out that followed removed the source of trouble. Since then, a slowing up of motors has been taken as an indication that a thorough cleaning is needed because the very small air gap is getting stopped up again. DONALD A. HAMPTON.

Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.

Eliminating Trouble by Replacing Crane Trolley Wires With Flexible Cable

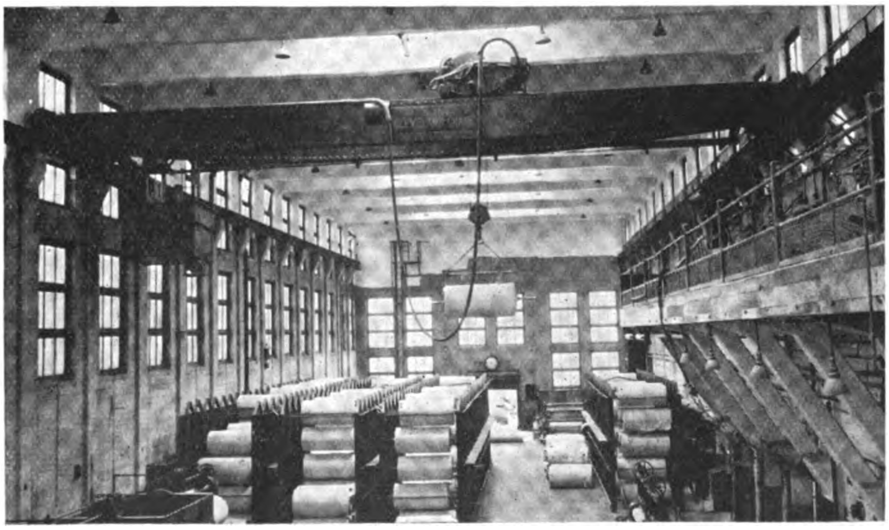
MAINTENANCE expense on electric traveling cranes in this plant has been considerably reduced and reliability of operation greatly increased within the past year and a half by replacement of the bridge trolley wires with multi-conductor flexible cables as described below.

The traveling crane equipment includes four 5-ton cranes with a maximum travel of 180 ft. and bridge span of 46 ft. The bridge rails are 29 ft. above the floor. Power supply to the motors is three phase, 60 cycles, 550 volts. The trolley drive motor, bridge drive motor and the hoist motor are respectively of 3, 15 and 30 hp. capacities and are all slip-ring motors controlled by drum controllers and secondary resistors.

The cranes are used for the distribution about the mill rooms of rolls of goods in process and cans of daub for coating the goods. During normal operation of the plant the crane shown in the accompanying photograph is required to make approximately 650 lifts in a period of 20 hr. thus allowing on the average about 2 min. for lifting, transporting and lowering a load. The crane is thus in use practically all of the time.

Breakdown of a crane in any one of the mill rooms seriously interferes with production especially where loads must be transferred from floor to balcony machines or the opposite. The practicability of the racks shown in the illustration for temporary storage of goods in process also depends upon reliable crane service. For the above reasons efforts have been made to make crane breakdowns as infrequent as possible. The possibility of cans of daub mixed with naphtha being ignited by sparks falling from poor contacts also necessitated removal of this hazard.

The original V-shaped, sliding shoe current collectors for the hoist and trolley drive motors were cut into by the No. 4 hard-drawn copper trolley wires on the bridge, which necessitated



The use of flexible cables in place of crane trolley wires on this and two other cranes improved operation considerably.

The old installation gave continual trouble and caused sparking which was a hazard due to the naphtha in use. Part of the trouble was removed by replacing the 9-ft. rails with 36-ft. rails and welding and grinding the joints. At the same time the sliding contacts were replaced with trolley-wheel collectors.

the making of frequent adjustments, replacements and inspections.

After a trial installation of trolley wheel collectors on one of the cranes all of the sliding contacts were replaced with standard wheel collectors with graphite bushings. These gave somewhat better service than the sliding contacts but did not reduce maintenance appreciably. Sparking at the contacts was caused mainly by vibration of the trolley wires which were spaced 4½ in. apart in vertical planes. The vibration of the wires in turn was attributable mainly to an unfortunate original installation of rails cut to 9-ft. lengths thus giving twenty rail joints to the length of the mill room. These rails have recently been replaced with 36-ft. rails and the joints have been welded and ground so that vibration from this source has been minimized.

Previously, however, to the replacement of the rails, the idea of using a flexible cable in place of the crane trolley wires was considered. After an experimental installation, permanent cables were installed on three of the cranes. The conductor system of the cable consists of ten No. 10 B. & S. extra-flexible (65 strands No. 28 wire) r.c. wires and three No. 2 extra-flexible r.c. wires. The ten No. 10 wires include the primary circuits to the two motors on the trolley, the secondary circuit of the 3-hp. motor and the limit switch conductor; the three No. 2 wires are the secondaries of the 30-hp. hoist motor. The thirteen wires extend from a terminal box, mounted on the side of one of the main bridge members in a readily accessible place above the cab, through 2½-in. Greenfield connected to the 2¼-in. rigid conduit which can be seen in the picture extending from the left end of the bridge along side of the carriage rail to a point near the center of the bridge. Here the rigid conduit connects to a 3-ft. piece of Greenfield which is strapped to a curved sheet-metal plate. From the junction of this section of Greenfield with the rigid conduit, through the loop, up to the junction box shown on the right side of the carriage, the conductors are carried in 2-in., internal diameter, 4-ply rubber hose, the last 6 ft. of which is pulled into another section of Greenfield. This part of the cable is supported by a rigid bracket bolted to the carriage and extending about 18 in. outside of the first section of the loop to allow for the passage of the trolley back and forth across the bridge without interference between the two sides of the loop.

The length of the loop is such that with the trolley at the extreme right of the bridge, there is sufficient clearance between the loop and the balcony railing without too much tension on the cable and consequent strain on its supports. With the trolley in the center of the bridge, there is a clearance of 5 ft. between the loop and the storage racks shown. Clearance between the ends of the journals on which the rolls are carried and the loop is sufficient so that in ordinary operation the journal cannot hook into the cable.

From the above, it is evident that the local conditions such as low amperage of the 550-volt motors which permitted the use of a comparatively light cable, the ratio of bridge length to height above the floor, and clearances, favored the installation of the cables and the resulting improvement in operation has warranted their use.

Two of the cables have been in operation over a year and a half and one since July, 1923. Except for an occasional adjustment, they have required no attention whatever to date. Holdups due to the troubles with the original wire and collector system have been eliminated; the fire hazard caused by sparks falling from poor contacts has been removed; and maintenance expense on the electrical equipment of the cranes has been reduced approximately 75 per cent. If the conductors break from repeated bending it will be comparatively easy to replace them. G. R. WELLS.

Plant Electrical Engineer,
The Standard Textile Products Co.,
Buchanan, N. Y.

How to Tie Underwriters' Knot in Lamp Cord

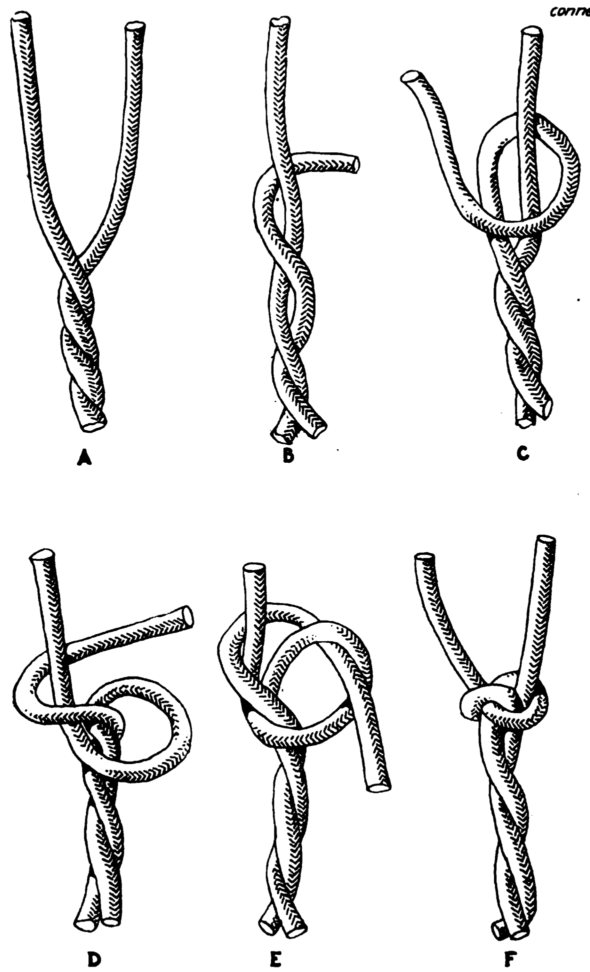
EVERY wireman knows that it is necessary to tie the ends of lamp cord after it has been inserted in socket caps and other fixtures, in order to avoid the possibility of the wires being jerked loose from the terminals by a strong pull on the cord. Also, if the ends are tied there is less likelihood of the cord untwisting. Oftentimes, however, the knot at the ends is improperly tied, so that it is much less effective than it should be. The illustration shows a sketch which I drew to show our men how the Underwriters' knot, as it is called, should be tied when making installations.

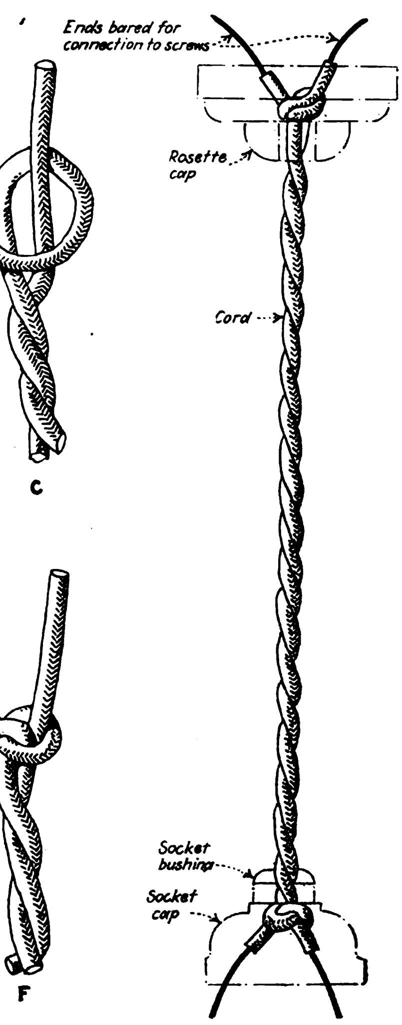
Starting with the ends of the two conductors slightly separated, as at (A), the one at the right is looped loosely around the other, passing back of and in front of it, as shown in (B) and (C). The second, or left-hand conductor is then bent to the left and looped, (D), around the first, or right-hand, conductor and the end passed through the loop formed by the first conductor, as in (E). When the knot is tightened by holding the two ends and pulling on the cord the knot will assume the shape shown in (F). The conductors can then be cut off to the desired length, the insulation skinned off and the wires fastened under the terminal screws as usual.

A knot made in this way will not slip or twist and, as shown at the right, is large enough so that it can not, under any ordinary circumstances, be pulled through the opening in the fixture.

San Juan, Porto Rico. F. KRUG.

Method of tying Underwriters' knot in lamp cord to prevent strain on terminals of sockets and fixtures.





Standard Power and Speed Ratings for Vertical Alternators

IN PLANNING for installations of vertical alternators of small and medium capacity it may be worth while to know what power and speed ratings may be obtained. The Electric Machinery Manufacturing Company, Minneapolis, Minn., have standardized in sizes

80% P.F.		Speeds at 60 Cycles																		
Kv-A	Kw	450	400	360	327	300	277	257	225	200	189	180	171	164	150	138	128	120	112	100
63	50				●	●	●	●	●	●	●	●		●	●					
75	60			●	●	●	●	●	●	●	●	●		●	●	●				
94	75	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●		
125	100	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
156	125	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
188	150	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
220	175	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
250	200	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
312	250	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
375	300	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
438	350	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		
500	400		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●			
563	450		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●			
625	500			●	●	●	●	●	●	●	●	●	●	●	●	●				
750	600			●	●	●	●	●	●	●	●	●	●	●	●					
875	700			●	●	●	●	●	●	●	●	●	●	●	●					
1000	800				●	●	●	●	●	●	●	●	●	●	●					
1250	1000					●	●	●	●	●	●	●	●	●					9440	

Vertical alternators of the standard power and speed ratings indicated by the black spots, may be obtained from one manufacturer.

from 50 to 3,000 kva. and at speeds from 72 to 600 r.m. The accompanying graphic chart gives the 60-cycle ratings of the small and medium sizes as standardized by this manufacturer. Each black spot on the chart represents a standard speed rating.

Unusual Combination of Grounds Cause of Trouble

THREE years ago a large industrial plant made a wage reduction in all mechanical departments. On the day this reduction went into effect all the plant executives were down early, to be on hand in case any trouble should arise over it. However, everything went along as usual, until about 10 o'clock, when the electrical department was suddenly flooded with trouble calls from all parts of the plant.

Right at this stage it appeared to be a well-planned and timed retaliation. On sifting out the various troubles it was found that a 1,000-kw. motor-generator set had grounded through the motor field; one of the field leads to an 800-hp. synchronous motor had burned off; and grounds had developed on half a dozen elevator and conveyor motor controls.

Naturally, it did appear mysterious at first that all these troubles should develop at once, but apparently the grounds on the elevator and general power feeders and motor-generator set motor field had been accumulating for some time. Then, when the ground developed on the 800-hp. synchronous motor field, a short circuit resulted. Owing to the arrangement of the circuit breakers on the switchboard, the only protection was through the main generator breakers, which were set at 8,000 amp. The net result was the burning of leads and damage to equipment that took the balance of the day to clear up.

After this occurrence ground lamps were installed in the substation at a negligible cost, and grounds have since been cleared up as soon as they develop. In this case these lamps have proved more satisfactory than a regular ground detector, for it is usually possible to locate the ground from the action of the lamps. For instance, in the case of an intermittent ground, such as on elevator controls, by observing the feeder ammeters in connection with the lamps the ground can be approximately located. Again, in the case of a more permanent ground, by furnishing the electrician with a report of the time on and off he has a good clue to work on without going through a tedious cut-and-try process. The advantage of the lamps over an indicator or voltmeter is that they are always under direct observation without being actually watched.

Another point to be brought out here is the apparent fact that single-pole trip protection is not sufficient on two-wire circuits fed from three-wire busbars, as in this case.

Akron, Ohio. E. J. del Vecchio.

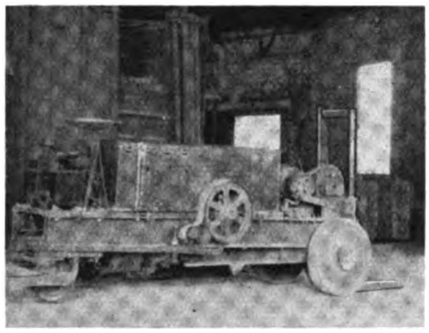
Construction of Annealing Kiln Charging Truck

TO FACILITATE the charging and emptying of a number of annealing kilns in a malleable-iron foundry, a handy and efficient truck was constructed, mostly out of material on hand from discarded trucks, together with some parts made by the machine department and a few which were purchased, mainly pinions. The truck is 12 ft. long over-all, 30 in. wide, 3 ft. high to the top of the battery box and 4 ft. 6 in. to the top of the lifting fork. It weighs 1¼ tons and is operated by two 1½-hp. battery motors, four-pole, series wound, 40-amp., 24-volts, 1,000 r. p. m. at full load. One motor is situated forward and drives 4-in. pinions meshed internally in both of the heavy front wheels. The front wheels are 20 in. in diameter and 4 in. wide, with iron treads shrunk on. The wheels are solid cast and turn on ball bearings. An 8-in. brake wheel is also keyed on the drive motor shaft. The brake band is a full circle and is operated through a toggle motion by the operator releasing the pedal.

The pots containing the castings to be annealed weigh from ½ to 3 tons and are lifted 4 in. by the fork, which is operated by a motor slung under the rear of the tractor. This motor, through a worm gear, tips a beam up and down, the movement of which is checked by a cam throwing out the electric switch near the operator. The lifting form is solidly cast on one end of the beam.

A pedal operates the main switch and releases the brake of the traveling motor. The tractor is steered by a 15-in. handwheel which turns the single rear wheel through a pinion. This wheel is solid, 12 in. in diam., 6 in. thick, and runs on ball bearings. A stop pin on each side prevents the wheel from turning too far in either direction.

All of the wiring is No. 6 flexible, stranded, rubber covered in 1¼-in. iron conduit. The battery power is supplied by twenty-five A-6 Edison cells, charging rate 45 amp. These are contained in trays of five each; sheet fiber is used between the battery and the sheet-iron case enclosing them to prevent grounding. The cover is also lined with sheet fiber to prevent short circuits against the caps of the cells. Large holes are provided all around the sides of the enclosing case to lead off the potash gas. A 100-amp. charging plug at the rear end of the battery box connects with the charging line.



This charging truck handles loads which formerly required five men to move.

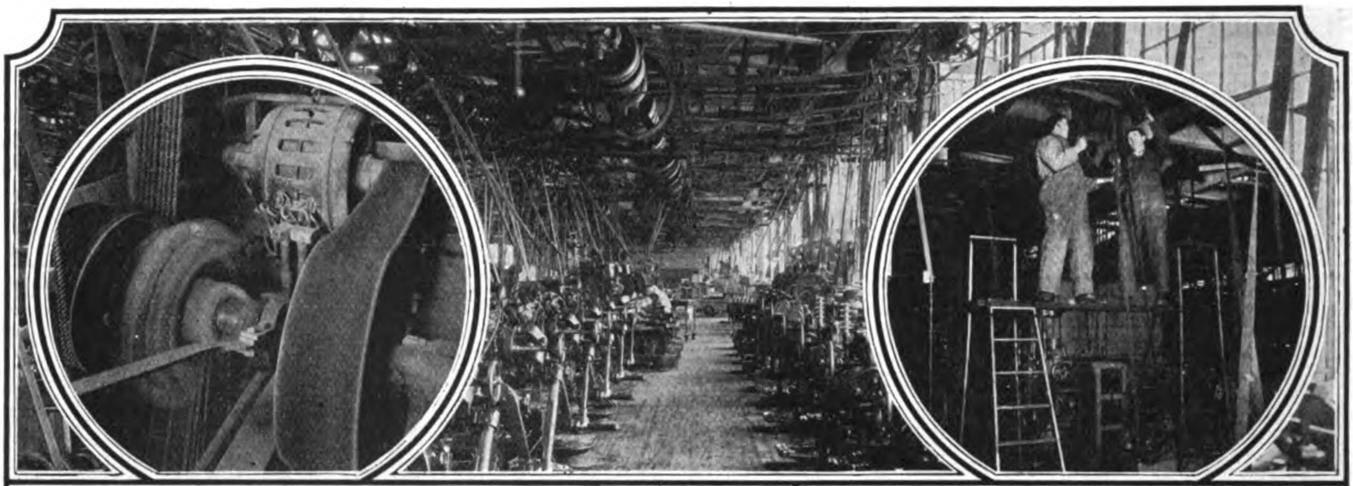
In addition the truck can do this work faster and go into hot places where men could not work. If not interfered with the truck can in 40 min. load or empty a kiln containing forty-two pots weighing 20 tons. It was made up largely of spare parts of discarded trucks.

The truck was tried out with the Edison A-4 cells, but a charge would not hold up for half a day under the heavy work done. The A-6 cells were then installed. The battery solution has to be renewed every four months. The tops of the cells are cleaned off frequently with compressed air, and the exposed wiring and leads varnished.

The kiln truck is worked so hard that the cells need watering every day. A charge of from 60 to 100 amp. is given for short periods, and a 50-amp. charge for eight hours every night. It is operated by one man, and when the road is clear he can load or empty a kiln and handle forty-two pots of castings, weighing 20 tons, in 40 min. The traveling motor is operated by a drum controller having three speeds forward and reverse.

A 100-amp. knife blade charging switch with enclosed fuses is installed on one side of the annealing room wall where the truck is stored when not in use. Alongside of this is an attachment plug receptacle which is handy for an extension lamp or drill when repairs are needed. The switch fuse and other live parts are contained in an asbestos-lined cabinet, with a pilot lamp on top wired to indicate whether or not the charge is on. A No. 00 rubber-covered two-wire line supplies the 115 volts direct current. The charging switch is closed for the night at 5 p. m. and is opened by the watchman at 1 a. m.

New Britain, Conn. H. S. Rich.



Mechanical Maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Application of Ball Bearings to General-Purpose Motors

THE many advantages gained by the use of ball bearings in all kinds of machinery from mill shafting to gyroscopes, from automobiles even to wheel-barrows, has so far demonstrated their usefulness.

Perhaps in no other field are the advantages in the use of ball bearings more apparent, and the benefits more certain than in that of electric motors. No special arrangements are necessary for belting in different directions. Up, or down, or on the side, makes no difference in their efficiency.

Motor efficiency is, of course, largely dependent on the maintenance of a uniform air-gap and as wear in properly made ball bearings is very low, it is evident that by their use a uniform relation between rotor and stator windings can be obtained.

In many instances the user of sleeve bearings holds to one make of motor, simply to keep down his stock of sleeve bearing replacements. The carrying of different bushings for two or three makes of motors represents considerable stock for which space must be provided. It also means quite an investment. All this is necessary with sleeve bearings, as each designer of motor bearings works out his own pet schemes in his sleeve-bearing design, with the result that every type and make of motor requires its own particular bearing. The use of ball bearings entirely overcomes this condition as the different makes of ball bearings are standardized to internationally-accepted dimensions. The modern, deep-grooved, chrome-steel ball bearing is now made to high-grade standards and in identical sizes by several manufacturers so that the sources of supply and reliability of service are well assured.

Motors, ball-bearing equipped, will give constant service provided the ball bearings are properly selected and properly housed. If, however, due to errors of design, ball bearings require replacements, provided stock is not available, the nearest bearing service station is in a position to give immediate service. These stations are established in all the larger cities and carry stocks of all the popular sizes.

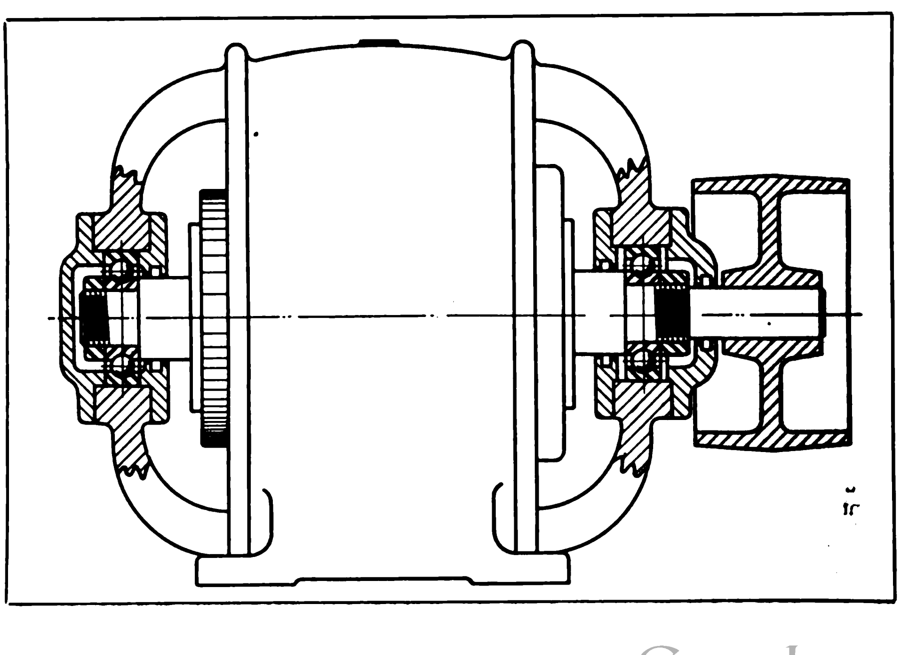
There are requirements today where no sleeve bearing will serve. For such places all makers now supply ball-bearing motors, even when the same maker does not supply or recommend ball bearings for his general-purpose line. Such a requirement is found in the driving motors for tilting tables in rolling mills. There the motor tips up and down as the steel is fed, first through the upper rolls and then through the lower.

The lubrication of ball bearings for motor service is best accomplished by allowing ample space around the bearing and packing with grease. This insures a clean motor with no oil soaked winding.

The proper application of ball bearings requires somewhat more careful machine work than is generally given to sleeve-bearing applications. It is also necessary that grit of any kind be excluded. This is easily accomplished with correct design. The accompanying drawing shows standard, ball-bearing practice. Note that the bearings are driven on the shaft against the shoulders. These shaft shoulders must be high enough to give a bearing against the flat face of the inside ring. On the larger sizes there should be also provided lock nuts as shown. On the smaller motors, however, pressed-on sleeves are sufficient. The end bell housings show one bearing held against side motion. This is accomplished by simply facing a small amount from the inside face of the end covers.

To make the application of ball bearings to electric motors the simplest possible stock proposition, the leading manufacturers of ball bearings have

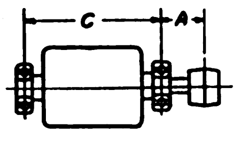
This detail drawing shows an accepted practice in the mounting of ball bearings in motors.



How to Use This Table for Finding Ball-Bearing Sizes for Use on Horizontal Motors

In the diagram at the top of the table *C* represents the distance between the centers of the motor bearings and *A* is the distance between the center of the pulley end bearing and the center of the face of the pulley. By means of these dimensions the pulley overhang ratio $(C+A) \div C$, is determined which together with the motor horsepower and speed and the pulley, belt and shaft dimensions are the factors governing the selection of the bearing. Bearing sizes are listed for a medium, heavy and wide series for the pulley end bearing, with alternatives for the heavy series and wide type, and also the sizes for the other bearing of the motor.

STANDARD BALL BEARING SIZES FOR GENERAL PURPOSE ELECTRIC MOTORS



Electric Power Club Standards			Horsepower			Recommended Annular Ball Bearings S.A.E. Standards					
						Pulley End					Other End
						Medium Series — Pulley Overhang Ratio $\frac{C+A}{C}$			Alternatives* — Ratio $\frac{C+A}{C}$ Not to exceed 1.40		Ratio $\frac{C+A}{C}$ Not to exceed 1.40
Pulley Dia. Ins.	Belt Width Ins.	Shaft Ext. Diam. Ins.	1750/1800 R.P.M.	1150/1200 R.P.M.	850/900 R.P.M.	Min 1.26	Max. 1.40	Avg 1.33	Heavy Series	Wide Type	
3	2	3/4	1			305	305	305			303
				3/4							
4	3	7/8	1 1/2			306	306	306			304
				1		305	305	305			
4	3	1	2			306	306	306			304
				1 1/2							
			3			306	306	306			304
				2							
5	4	1 1/8	5			307	307	307		306	305
				3							
					2						
5	4	1 1/4	7 1/2			308	308	308		307	305
				5		307	308	307			
					3	307	307	307			
6	5	1 3/8	10			309	310	309		308	306
				7 1/2		308	309	308			
					5	308	308	308			
7	6	1 5/8	15			310	311	310		309	307
				10		309	310	309			
					7 1/2	309	309	309			
8	6	1 3/4	20			312	313	312	410	311	308
				15		311	312	311		310	
					10	310	311	310		310	
9	7	1 7/8	25			313	314	314	411	312	309
			30			314	315	314	412	312	
				20		312	313	313	411	311	
					15	312	312	312	411	311	
10	7	2 1/8	40			315	316	315	413	313	310
				25		313	314	314	412	312	310
				30		314	315	314			
					20	312	313	313			
					25	313	314	314			
11	10	2 3/8		40		315	316	316	413	314	311
					30	315	316	315		313	
12	11	2 5/8		50		317	318	317	415	315	312
				60		317	318	318	415	315	313
					40	316	317	317	414		
13	12	2 7/8		75		318	319	319	416	317	314
					50	317	318	318		316	
					60	318	319	319	416	317	314
15	14	3 3/8		100		319	320	320	418	318	316
					75						

* SHAFT STRESSES SHOULD BE CONSIDERED WHEN ALTERNATIVES IN HEAVY SERIES OR WIDE TYPE ARE USED

The engineers of the several American manufacturers of ball bearings listed below have recommended as engineering standards of the industry the accompanying ball-bearing sizes as applying to horizontal, general-purpose electric motors having present Electric Power Club pulley diameters, belt widths, shaft-extension diameters and having pulley overhang ratios lying between the maximum and minimum values as shown. These standards do not apply to motors for special purposes nor to those having dimensions and overhang characteristics beyond the range given in the table. The engineering departments of these companies will gladly furnish additional data and recommendations for the application of ball bearings to special conditions not covered herein:

The Fafnir Bearing Co.; Marlin-Rockwell Corp., successor to Gurney Ball Bearing Co.; The New Departure Manufacturing Co.; SKF Industries, Inc.; Strom Ball Bearing Manufacturing Co.; Standard Steel and Bearings, Inc.

given most careful consideration to the requirements of this service. In the preparation, nearly every American make of motor was studied. The accumulated data shown in the accompanying table was turned over to a Committee of Ball Bearing Engineers who had made a special study of electric motor requirements. The recommendations in the Committee report were drawn up and subscribed to by the co-operating companies.

This recommendation is the collective experience of the Committee, and is a safe guide for bearing selection when its conditions are complied with.

It will be noted that these specifications, covering a range of motors from ¾ hp. to 100 hp., require a total of only sixteen sizes of ball bearings for all sizes of motors, with an alternative of nine additional sizes for extra-heavy duty on the larger motors. These bearings are standard sizes, not only in this country, but throughout the world. The unanimous endorsement of bearing sizes by practically all of the leading manufacturers of bearings not only relieves the motor manufacturers from the danger of improper selection of bearing sizes, but insures to the user the utmost in reliable and efficient performance and easy replacement in case of accident. In every way these specifications should mark a distinct advance in standardizing motor design.

[These statements concerning the use of ball bearings in motors were taken from recent engineering literature issued by The Fafnir Bearing Co., New Britain, Conn., and The New Departure Mfg. Co., Bristol, Conn.]

Tests Prove Which Side of Leather Belt to Put Next to Pulley

BECAUSE some users of leather belting are in disagreement as to whether the grain (hair) or the flesh side of the leather belt works best next to the pulley the Leather Belting Exchange, an association of manufacturers of leather belt, ran a series of tests in its laboratory in connection with Cornell University. For these tests, five first-quality, 4-in. leather belts made by different manufacturers were used over two 24-in. pulleys operating at a shaft speed of 500 r.p.m., or 3,100-3,200 ft. per min. belt speed, which was selected as being of average shop speed. Tests were run at tensions of 36 and 54 lb. per in. of width. In all of the testing work it was found necessary to run-in the test belts thoroughly before any final conclusions were drawn.

The fact that the flesh side has nearly its maximum capacity from the first while the grain side requires more running-in, may lead an inexperienced user to conclude that the flesh side is the best for transmission. In one case, the first test on the grain side was below the first on the flesh side, and yet the grain side after 6½ hr. of running-in surpassed even the final tests on the flesh side. With further running-in this improvement continues until the grain side transmits three times as much power as the flesh side.

None of the five belts transmitted its full capacity when first put on. Usually the better belts improve the most rapidly, but this is not always so. The rate of improvement does not seem to be constant, but varies throughout each period of running-in. In some cases the flesh side tends to decrease in capacity with continued running-in. The conclusions reached were:

(1) Under the average shop tensions, the flesh side averages from 58 to 68 per cent of the capacity possessed by the grain side.

(2) In general, the grain side will transmit from one to three times as much power as the flesh side, depending on the belt, the tension, and the conditions of service.

(3) With some belts the flesh side has a greater capacity than the grain side when first put on the pulleys, but in no case was a higher capacity obtained for the flesh side after the belts were thoroughly run-in. This is because the flesh side usually had nearly its maximum capacity at the start without running-in, while the grain side required a period of running-in to reach this point.

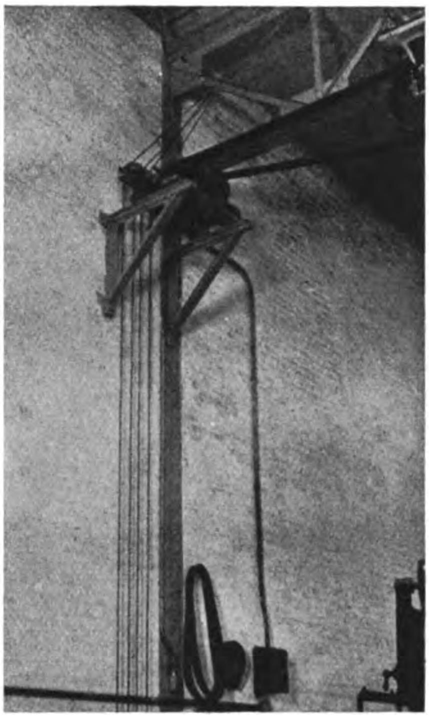
(4) Where there is an increase in the capacity of the flesh side due to running-in, it is usually less than the corresponding increase due to running-in the grain side.

(5) The capacity of the flesh side may decrease slightly with continued running-in.

(6) The time of running-in on the grain side, required to bring these belts up to rated capacity (20-25 hp.), varied from 5 hr. with the better belts, to 40 hr. with the poorest. To bring them to approximately maximum capacity required from 20 to 63 hr.

Novel Use of Wall Brackets for Mounting Motors

WHEN mounting motors on a wall, it is not always necessary to forge out triangular arms or braces to support the mounting platform. In the new Chicago plant of the Brunswick-Kroeschell Company, ordinary cast-iron wall brackets which are used for supporting lineshaft hangers or pillow blocks, were attached to the wall and used as a support for the motor platform, as shown in the accompanying illustration. Each bracket has a



Here the motor is mounted on an easily-constructed platform.

Instead of building a special iron framework upon which to mount the motor platform, these cast-iron wall brackets were attached to the wall. T-grooves made it easy to bolt the platform on to the bracket and also permit of adjusting them as desired. The motor is controlled by a push button as shown. The four chains are used for opening sash in the monitor roof.

T-groove to which the platform may be bolted without the necessity of boring any holes in the iron frame. Many plants have surplus equipment of this sort on hand which could be used in this way. It would probably be as economical and as easy to purchase new brackets as it would to make a special iron framework.

Operating Belts Where Pulleys Are Close Together

EXPERIENCED millwrights know of the risk involved in running two belts on one pulley. It does not make any difference whether the belts take off in the same or opposite directions. The least side slap, which causes the belts to touch, or the breaking of a belt results in a disaster of greater or less degree. The same is true of two pulleys of different diameters that are placed side by side, because belts have a propensity for crowding toward each other and the inevitable accident follows.

It is for this reason that the experienced man always leaves plenty of room between pulleys. Good practice requires a space wider than the width of either belt and it is preferable to make that space double if there is any way of arranging drives to this end. A common practice, though one not recommended, is to fasten a stick from overhead so that it keeps the belts separated; this, however, is weak because it occupies so little space and a belt can sway or its free end slap around the stick until it comes into contact with the other belt on the moving pulley.

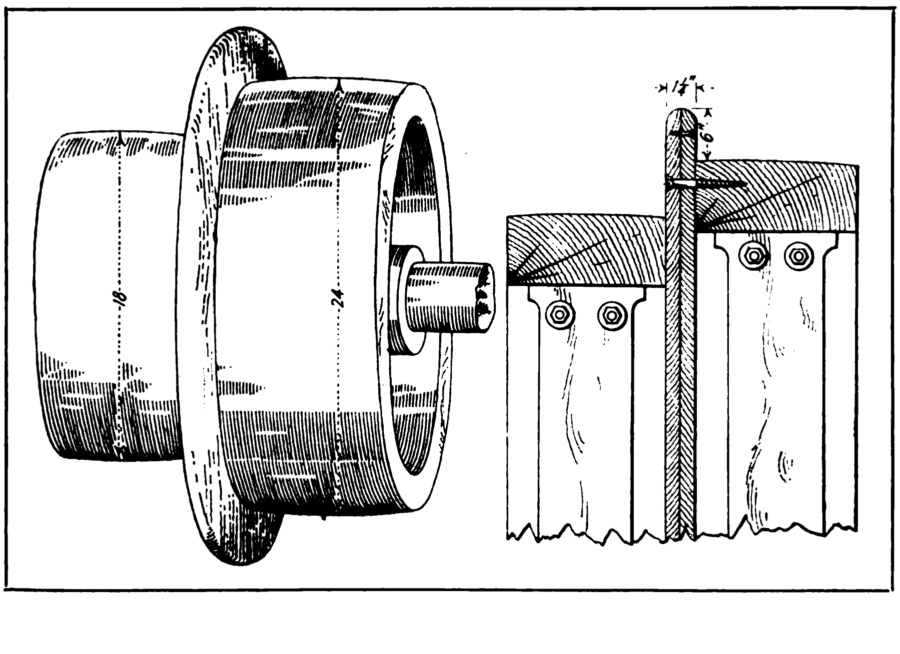
One plant in the screw products industry found that its production arrangement of machines called for a score or more of these danger points. A 24-in. pulley had to be set on the line-shaft tight up against an 18-in. pulley with no good way to avoid it if floor space were to be conserved. The plant was built in 1917 and these pulleys have been run safely and satisfactorily ever since by the scheme shown below. The belts from these pulleys run in opposite directions.

A wooden flange was made up for each pair of pulleys. No attempt was made to skimp on the quality of the lumber or to make a cheap job, for it was realized that to be of any good at all, the flange must be made right. At that, the cost was low because the full number were made at once which greatly lessened the set-up time.

Seasoned maple was used for the flanges which were made in the form of discs, laminated to minimize warping, and with the plies laid at right angles. Commercial "one inch" stock was used which usually planes to 25/32 in. It was planed still thinner in order that the finished flange would not occupy more than 1¼ in. longitudinally on the shaft.

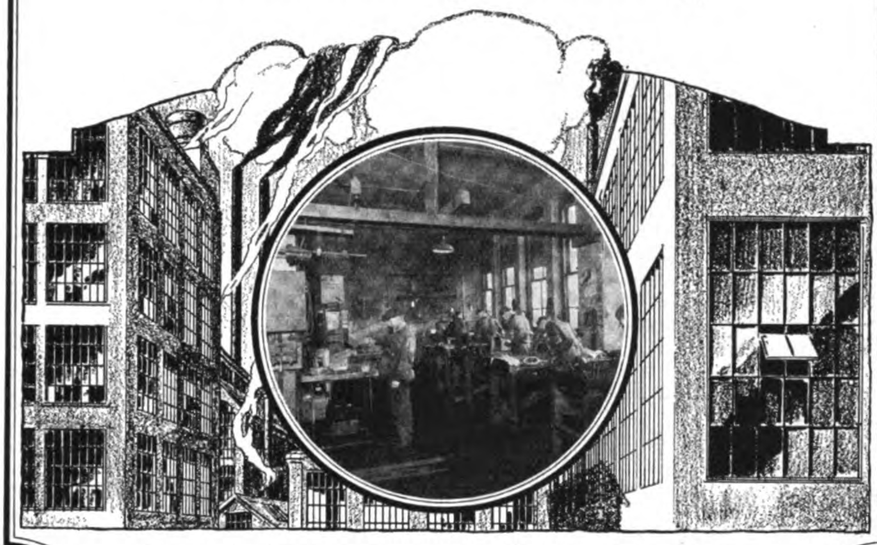
Referring to the drawing, it will be seen that the separate plies are screwed and glued together and that the whole is screwed to the rim of the larger pulley and split, becoming to all intents a part of the pulley. These were placed on a mandrel and lathe turned to make them concentric and true and the corners well rounded to prevent belt chafing.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.



With this special flange belts are run in opposite directions, although the pulleys are placed close together.

In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Portable Post Bench with Vise for Construction or Repairs

FORMERLY in a structural iron shop the work required the use of pipe vises at various positions throughout the shop. These were fastened with lag screws to the wooden posts which supported the roof. The posts were drilled and the lag screws holding the vise base were screwed directly into the posts.

Obviously abuse and contact with plates and girders which were being swung about was detrimental to the life of the posts and in a few years they were replaced by steel columns. The foreman then decided it would be unwise to drill each of the columns for bolting the vises into position, while at the same time facilities for grouping vises adjacent to the work were desired.

To accomplish this a vise-handling method was adopted, which is shown in the illustration. However, this has features which make it a most desirable idea for any shop requiring either portable pipe or bench vises or for repairmen. Several oak blocks 6 in. x 6 in. x 3 ft. were made with undercut or mortised sections about an inch deep at the center to fit the columns as shown. Each of these blocks was bored near the ends for long through-bolts. At the ends of these blocks, both top and sides, holes were drilled for attaching pipe or bench vises. These blocks are readily removed and may be stored in the corner of the shop when not in use. Whenever vises are needed, it is only a matter of putting up two blocks and inserting the through-bolts. One or more vises can then be placed to meet any requirements. Apart from the portable and removable feature of these improvised benches, they are adjustable for height and have a space in which tools may be placed, which is a distinct advantage.

Washington, D. C. G. A. LUERS.

How to Locate Common Troubles in Armatures

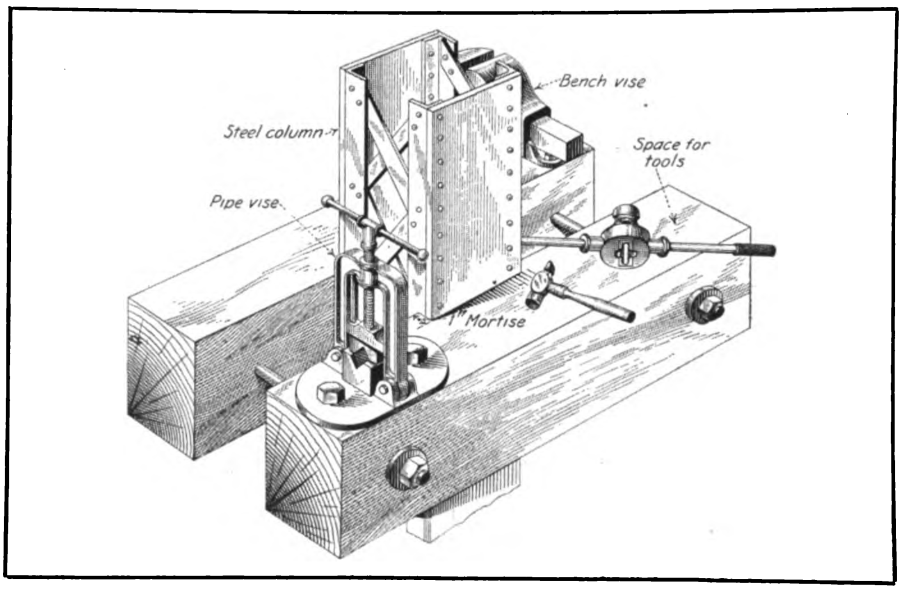
DEFECTS in the armatures of direct-current motors and generators show up in various ways but can ordinarily be located without a great deal of difficulty. If a few of the symptoms and causes of the more common defects are well known, the diagnosis and location of these troubles is still further simplified. For this reason the following suggestions may be of interest to readers of INDUSTRIAL ENGINEER.

A short circuit in an armature coil is a very frequently encountered trouble which is indicated by flashing at the commutator and heating of the armature and will result in burning out of the coil unless it is cleared up. This defect is usually caused by metallic particles of some kind bridging across the insulation between the commutator bars, by the risers being knocked together, on lap-wound armatures, or by one or more turns of the coil coming into direct contact and causing a short circuit.

The faulty coil can usually be located by its excessive temperature compared to that of the rest of the coils, by the baked appearance of the insulation of the faulty coil or by measuring the resistance. If the trouble is in a generator the brushes can be raised from the commutator and with the fields properly excited the armature may be rotated for a few moments at a time. The short-circuited coil, which is of low resistance, will generate a heavy current causing it to heat.

A ground at one point in an armature winding will not always cause serious trouble, although it is a source of danger to the operator, but if the insulation should break down at a second point in the winding a short circuit is produced and a burn-out will result. A good method of locating a grounded armature coil is to pass a direct current of a few amperes through the armature by its own brushes. Touch one terminal of a voltmeter, or a galvanometer which is not too sensitive, to the shaft of the armature and with the other terminal lead make contact with the commutator bars in succession until contact with a certain one of the bars will show no deflection of the instrument. The coil connected to this bar or the bar itself will be found to be grounded. If a galvanometer is used, care should be taken to keep it far enough away from the armature so that it will not be affected by the armature magnetism.

A ground or partial short circuit be-



Although this post bench was made for the Production Department, repairmen will find it useful.

With several pipe and bench vises, like these mounted on 6-in. x 6-in. timbers it is easy to erect a temporary stand almost anywhere in the shop. Where repairmen have a truck to carry their tools around a pair of these blocks may be included.

tween coils is manifested by heating and sparking. In the case of a bipolar generator, excite the field coils and turn the armature over by hand. It will be found that the armature will turn quite hard until it reaches a certain position, where one-half of the armature will oppose the other half. At this position mark the armature at the center of the pole pieces and the trouble will very nearly always be found in coils under the marks. If the generator is multipolar, all but one north and one south pole directly opposite should be cut out of circuit and all of the brushes lifted except those for the two active poles. The field may then be excited and the test made as above. The same test holds good for a motor; excite the field and limit the current in the armature to a value at which the armature will just rotate. Then by turning the armature by hand against rotation a position will be found at which the armature will have no torque. It will be found that the coils directly under the middle of the pole faces when the armature has no torque are the faulty coils.

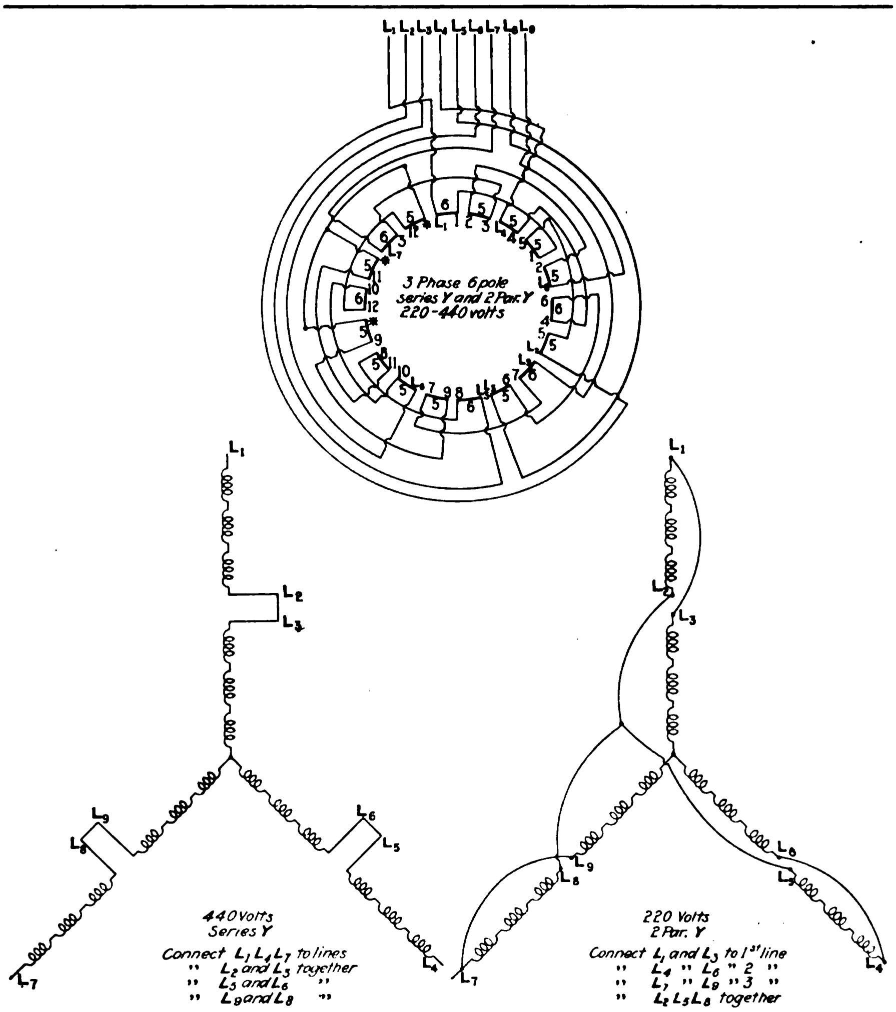
An open circuit or high resistance in the armature circuit causes heavy flashing at the brushes and produces flat spots on the commutator. There will be sparking each time the segment to which the coil is connected passes under a brush. This trouble is distinguished from that caused by a short-circuited coil by the fact that the armature as a whole is not heated. The open circuit or high resistance is usually found on the commutator or riser, whichever it may be. As a rough test, in case of high resistance in the armature, if a current of a few amperes can be sent through the faulty coil the point of high resistance can be located by the heat developed there. Another method of locating these faults involves the use of an ammeter connected to a low-voltage source of current. The terminals should be small enough to rest on a single commutator segment and should be applied to the commutator at two opposite points. The ammeter reading should be noted and the armature rotated slowly. At the point where the open circuit is located the reading will drop to zero.

Muncie, Ind. GEORGE CROPPER.

Motor Rewound for Two Voltages and Different Speed

AN INTERESTING problem came up recently in connection with rewinding a motor for operation on two different voltages, with a change in speed. This was a Westinghouse motor, type CCL, three phase, 60 cycle, 10 hp., 220 volts, 25.8 amp. per terminal, 850 r.p.m. The old winding consisted of forty-eight coils of sixteen turns each of three No. 14 d.c.c. wire, in ninety-six slots, coil pitch 1-and-12, connected two-parallel star. The owner wished to have the motor rewound for 1,200 r.p.m., increasing the horsepower to 15, if possible. He also wished to have the winding connected so that the motor could be operated on either 220 or 440 volts.

Method of connecting three-phase, six-pole motor for operation on 220 or 440 volts.



Checking the horsepower, the new rating of this 900-r.p.m. motor would be $(1200 \times 10) \div 900$ equals $13\frac{1}{3}$ hp., but according to data on hand, this frame is good for 15 hp. at 1,200 r.p.m. At 440 volts the amperes per terminal would be 20 amp.; at 220 volts, 40 amp.

The old or 900 r.p.m. winding consisted of $48 \div 3 = 16$ coils per phase, with 16 turns per coil or a total of $16 \times 16 = 256$ turns per phase. Then for 1,200 r.p.m. the turns per phase equal $(256 \times 900) \div 1{,}200$, or 192 turns. As a two-layer winding was required, there would be ninety-six coils, with $96 \div 3 = 32$ coils per phase. The turns per coil would be $192 \div 32 = 6$ turns per coil. The size wire would be $(256 \times 12{,}321) \div 192 = 16{,}428$ circ. mil. One No. 14 wire has an area of 4,107 circ. mil, and three an area of 12,321 circ. mil. Then $16{,}428 \div 4 = 4{,}107$; therefore, four No. 14 d.c.c. wires would do. The new two-layer coil would have six turns of four No. 14 d.c.c. wires per coil, or $2 \times 6 \times 4 = 48$ wires per slot; the old winding had $16 \times 3 = 48$ wires per slot, both windings having the same space factor.

The eight-pole pitch was 1-and-12; full pitch would be $96 \div 8 = 12$ or 1-and-13. Then 1-and-12 is $11 \div 12 =$ .92 or 92 per cent pitch. The six-pole pitch would be $(96 \div 6) \times .92 =$ 14.72 or 1-and-14 would do.

The chord factor of the 1-and-12, eight-pole pitch was $96 \div 8 = 12$, and 180 deg. $\div 12 = 15$ deg. Then the sin of $(11 \times 15) \div 2$ or 82 deg. 30 min. equals .99144 and the chord factor of the 1-and-14, six-pole pitch would be $96 \div 6 = 16$, and $180 \div 16 = 11.25$ deg. The sin of $(11.25 \times 13) \div 2$ or 73 deg. $7\frac{1}{2}$ min. equals .9569. The 1-and-14 pitch would be satisfactory, as increasing the pitch would also increase the coil projection beyond the iron and require more copper.

For six-poles, three phase, there would be $3 \times 6 = 18$ pole-phase groups, and with ninety-six coils there would be twelve groups of five coils in series and six groups of six coils in series, arranged as follows: 655, 556, 565, 655, 556, 565.

The motor was to be connected to operate on 220 or 440 volts and this was accomplished by using nine leads, making possible a series-star and a two-parallel star connection. The diagram shows this arrangement, and the method of making the change outside the motor.

The 1,200-r.p.m. data was, then, 15 hp., 220-440 volts, 40-20 amp. per terminal, three phase, 60 cycles. There were ninety-six coils, each coil consisting of six turns of four No. 14 d.c.c. wires in parallel, pitch 1-and-14, connected series-star for 440 volts, and two-parallel star for 220 volts.

Pittsburgh, Pa. A. C. ROE.

Laying Out Wave Windings

(*Continued from page 489*)

placed on the A_1 and C_1 leads so as to point into the winding, then the arrow on B_1 should point out of the winding. In the schematic sketch shown at the lower right-hand corner of Fig. 12, the A_1 and the C_1 leads are given a polarity such that the arrows point into the winding and the B_1 lead has a polarity such that the arrow points out of the winding. Then for the series-delta connection to be correct, in tracing around the delta, you should be able to follow through one phase against the arrow and the remaining two phases with the arrows; or if you started the opposite way, you would have two consecutive phases against the arrows and through the third phase with the arrow.

The next point in our consideration of wave windings is to determine how many circuits it is possible to secure. We will first consider the one-coil-per-cell, two-layer winding. This type of winding can only be connected in series or two-parallel. The way the two-parallel connection is obtained is shown in Fig. 16. This figure shows a four-pole, two-phase, left-hand winding, which is similar to the winding shown in Figs. 7 and 8. In any wave winding of this type, each phase is divided into two equal sections having two leads per section, or four leads per phase; that is, there will be two ingoing and two outgoing leads per phase. In Figs. 8 and 16 the two ingoing leads are B_1 and R_4 for the B phase and the two outgoing leads for the B phase are B_2 and R_3. If we remove the reversing jumpers and connect R_3 to B_2 and R_4 to B_1, and attach a line lead to the junction of each of these pairs of leads, we will have divided the phase in half, cutting down the turns 50 per cent and increasing the current-carrying capacity 100 per cent. In the A phase, the A_1 line lead is connected to the A_1 and R_2 leads and the A_2 line lead is connected to the A_2 and R_1 leads; that is, the starting leads of the two sections of the same phase are connected to one line and the finishing leads to the second line.

Fig. 17 shows how the three-phase, series-star connected winding shown in Fig. 11 was changed to make a two-parallel star-connected winding. First, open the reversing jumpers and connect the end of the first section of one phase to the star ring, and the other jumper lead, which is the start of the second section of the same phase, should be connected to the line lead that connects to the start of the first section of this phase. For the A phase, the first reversing jumper lead, R_1, will be connected to the star ring as shown in Fig. 17. The second reversing jumper lead, R_2, will be connected to the line lead that connects to the start of the first section; that is, it will connect to A_1 as is shown in Fig. 17. This procedure should be repeated for each phase. Then each line will have connected to it the starting lead of both sections in that phase and the finishing leads of all sections will be connected to the star ring. This layout is shown in the schematic sketch in the lower right-hand corner of Fig. 17.

The method of making a change from a series-delta to a parallel-delta connection is shown in Figs. 12 and 18. In Fig. 12, as was explained previously, is shown a series-delta connected winding. Fig. 18 shows the same winding connected parallel delta. The method of making a change from series-delta to parallel delta is to locate the line and reversing leads of each phase; then open the reversing jumper and connect the starting lead of the second section to the starting lead of this phase. Likewise, connect the finishing lead of the first section to the finishing lead of this phase. For the A phase, this would mean that R_2 would be connected to A_1, and that R_1 would be connected to A_2. Repeat this for each phase. Then the parallel sections, which we now have should be connected in delta as was explained previously. Each line lead should then have two top and two bottom leads connected to it. This is clearly shown in the schematic sketch in the lower right-hand corner of Fig. 18.

When a winding consists of two or more coils per cell it is possible to get still further parallel reduction. For example, take the winding shown in Figs. 13, 14 and 15. In this winding which has two coils per cell, it is possible to parallel the coils per cell, thus making it equivalent to a one-coil-per-cell winding of twice the cross section. Then the sections of the winding could be paralleled as shown in the previous paragraph. Hence, the conclusion may be drawn that it is possible when a winding has two coils per cell, to get the equivalent of a four-parallel connection regardless of the number of poles in the winding.

To parallel the two coils in any one cell, it would not be necessary to remove all the connecting clips and join each coil to its mate. The same effect could be obtained by removing the clips between the beginning and end of each section or at four places in a two-phase winding and at six places in a three-phase winding. The end and start of each slot series could then be reclipped and thus parallel the coils per cell. For example, in Fig. 13, we could remove the clip that connects lead O to top lead M, connect M to N to form the phase lead, remove the clip from P and L, then connect K and L to O and P, with the result that we would have coils *3*, *1*, *4* and *2* in parallel without disturbing the connections at Y. It is obvious that the larger the number of poles the greater would be the time saved by this method. In Fig. 14, after opening the connection between S and K, S and T would connect together, to form the R_1 lead. Leads O, P, K, and L would be connected together to form a short pitch connection. The same procedure could be followed for each of the other sections.

When a winding has three times as many coils as slots, the voltage can be reduced one-third and then one-half again, by paralleling the three coils per cell and then paralleling the sections of the winding. It is useless to try to get a four-parallel connection by paralleling the two coils in one slot and the remaining coil in this slot to one of the coils in an adjacent slot, even if the number of slots and coils permits it. The coils in the two separate slots are out of phase and would set up circulating currents and heat the motor. This was explained in the last paragraph on page 429 of the September issue of INDUSTRIAL ENGINEER, in which the first article of this series appeared.

With four coils per cell, the winding can be divided into four parallels by paralleling all the coils in one slot and if the sections of the winding are then paralleled, the equivalent of an eight-parallel connection would be obtained. In any case, to parallel the coils per slot, it is only necessary to reclip the coils at the point where the short pitch occurs.

In the third article of this series will be given tabulations that will help the winder lay out wave windings and greatly shorten the work of constructing a winding diagram.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Page Belting Company, Concord, N. H. —A 28-page booklet, entitled, "Leather Link Belting," describes and gives a number of the applications in which link leather belting may be used to advantage. These belts are made of short links of leather fastened together by pins. These links are applied on edge to the pulley. This belt is claimed to have long life and operate well under many severe operating conditions.

Mitchell-Rand Manufacturing Company, 18 Vesey Street, New York, N. Y.—Twenty-one samples of hard maple wood armature wedges are placed in an envelope with an eyelet so that it may be hung up in the shop. These samples are placed loosely in the envelope so that they may serve as gages to check the size desired for any piece of work. Formerly these were glued to a card. The size and type of each sample wedge is stamped on it. The envelope also contains a complete price list.

Superior Switchboard and Devices Company, Canton, Ohio—A 36-page booklet, entitled, "Meterology," is of handy pocket size for quick reference. It has been compiled for the aid and convenience of meter men and contains practical data and diagrams of meter and switchboard installations.

Trico Fuse Manufacturing Company, Milwaukee, Wis.—A folder describes the new Trico handy pocket-size fuse puller and replacer for all fuses up to 200 amp., 250 volt, and 100 amp., 600 volts. This is made of the highest grade genuine gray horn fiber and tested at 35,000 volts.

The Hullhorst Micro Tool Co., Toledo, Ohio—A new illustrated folder describes the construction and operation of the Hullhorst mica undercutting machines. These are made in two types: portable and for use in a lathe, on either a.c. or d.c. supply.

The Drake Electric Works, 3943 Lincoln Avenue, Chicago, Ill.—Catalog 703 describes the Drake mechanics, soldering iron with removable tips and heating element of nichrome wire wound on a lava core.

Century Electric Company, St. Louis, Mo.—Form 532 describes and illustrates several applications of Century motors for pumps and compressors.

The Cutler-Hammer Manufacturing Company, Milwaukee, Wis.—Publication 3,217 entitled, "Safety in The Rubber Mill," makes particular reference to the application of the C-H magnetic clutch brakes in rubber mills, where they are used to secure quick stopping of mixing and cracking rolls, washers and calenders when accidents occur. These can be used on any rotating machinery that must be stopped instantly, either in its operation or in an emergency.

Bird Machine Company, Pulmax Drive Division, South Walpole, Mass.—A 30-page catalog describes the "Pulmax Short Center Drive," discusses the principle of its operation and its advantages by illustrating various applications. This is a special device for increasing the arc of contact of the belt on the smaller pulley without excessive increase in tension.

The Williams Foundry and Machine Company, Akron, Ohio—Catalog 10 covers the 19 sizes of Akron friction clutches ranging from ¾ to 1,000 hp. at 100 r.p.m. The clutch is of the disk type which is applied by rollers in the toggle arm. Several pages are devoted to useful data and tables.

Reliance Electric and Engineering Company, Cleveland Ohio—Bulletin 2016 describes the Type T heavy-duty Reliance planer motors for reversing service. In addition to a complete description of the motor and its advantages a number of illustrations are given showing planer installations.

Irvington Varnish and Insulator Company, Irvington, N. J.—Catalog 101, entitled, "Irvington Insulation" describes the various insulating materials, and also the method of applying and other facts concerning the use of the different insulating varnishes.

Ohio Brass Company, Mansfield, Ohio —Circular describes the O-B 500 volt arc welder of the series resistance type which is specially designed for rail bond welding.

The O. C. White Company, Worcester, Mass.—A circular entitled "Applied Lighting" shows the various styles of adjustable wall and bench fixtures, as well as floor stands for industrial lighting.

Crouse-Hinds Company, Syracuse, N. Y. —Folder 11 describes and illustrates an interlocking switch and plug which is claimed to be 100 per cent foolproof, simple in construction and positive in action. With this it is impossible to withdraw the plug or open the door of the fuse department unless the safety switch is open and also impossible to close the switch unless the plug is fully inserted and the door of the fuse compartment is closed.

Charles Cory & Sons, Inc., 183-7 Varick St., New York, N. Y.—Catalog bulletin 50-A describes the Cory antinoise inter-communicating telephone with magnavox loud-speaking features for marine and noisy industrial applications. Bulletin 103-A describes the Cory-Recony control for electric operation of valves. Bulletin M-104A, covers the Cory signal system for electric visible signals for communicating routine instructions as may be used between important points in central stations, mines, pumping plants and other industrial fields. Bulletin 105-A describes the Cory-Robinson disconnecting switch interlock which prevents unauthorized persons from getting at the connecting switches, instrument transformers, and other disconnecting units in bus and feeder lines. Bulletin 101-29-B covers the Cory-Record ohmmeter for testing the insulation resistance of electrical apparatus, machinery and cables.

Albert & J. M. Anderson Manufacturing Company, 289-305 A Street, Boston, Mass.—Bulletin 37 describes the several kinds of automatic time switches, gives a number of the various applications and instructions for their operation.

Truscon Steel Company, Youngstown, Ohio—This literature describes a new type of steel pole for transmission and lighting purposes pressed from steel channels or I-beams.

Industrial Controller Company, Milwaukee, Wis.—Bulletin 2200-B covers alternating-current, hand-operated compensators, Type C, with oil immersed switches for starting polyphase motors. Bulletin 8527-8526 is on the alternating-current, across-the-line type of starter with low-voltage and overload protection. This may be operated from a push button station or by automatic starting devices. Bulletin 8605 describes the alternating-current automatic compensator with oil-immersed contacts for use in starting polyphase squirrel-cage motors. This is built for remote control and automatic or hand operation.

Leeds and Northrup Company, 4901 Stenton Avenue, Philadelphia, Pa.—Catalog describes the apparatus and method of the hump method for the treatment of steel. This consists of the use of an electric furnace with manual control equipment, a single-point recording potentiometer to indicate the proper quenching point and a quenching tank.

Foote Bros. Gear and Machine Co., 213-221 North Curtis Street, Chicago, Ill.—A new bulletin "Foote IXL Flexible Couplings" describes, with prices and dimensions, this company's line of flexible couplings for every purpose and ranging in size from the smallest units made to couplings for transmitting several hundred horsepower. It contains much practical information on the use of flexible couplings and will be sent to anyone interested.

Electric Furnace Construction Company, Jefferson Building, Philadelphia, Pa.—A folder illustrates a number of installations of electric heat-treating, enameling furnaces, arc smelting furnaces and electric steam boilers.

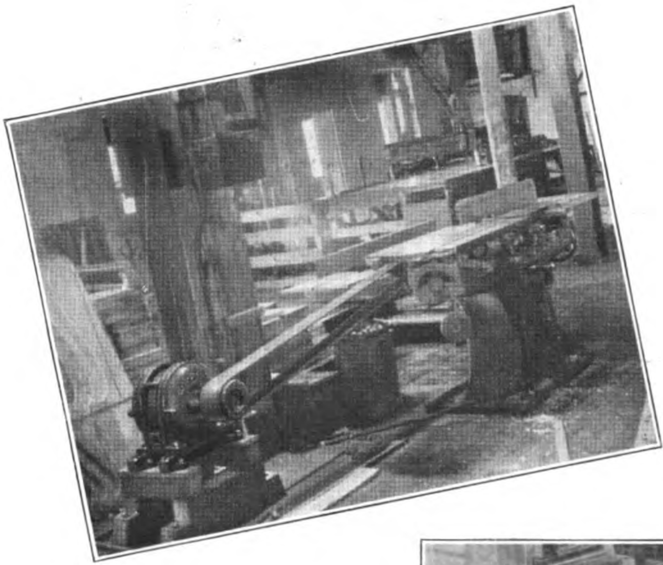
Century Electric Company, St. Louis, Mo.—A folder illustrates by means of a cut-away photograph the construction of a repulsion-start, Century, single-phase induction motor. Arrows and explanatory notes point out and explain special features of construction.

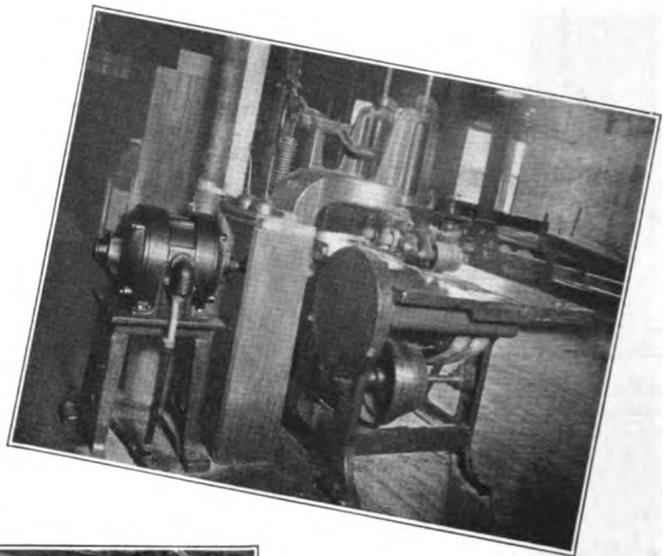
Roller-Smith Company, 229 Broadway, New York, N. Y.—Bulletin 160 describes the Type GSA alternating-current portable instruments, such as ammeters, voltmeters, volt-ammeters, single-phase and polyphase wattmeters, frequency meters, power factor meters, transformers, multiplies and "Y" boxes.

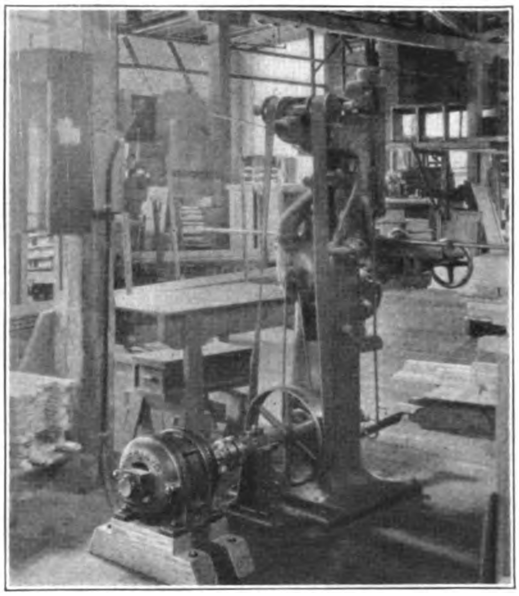
Founded 1882 as Electrical Review | November, 1924 | McGraw-Hill Co., Inc., Chicago, Ill

Industrial Engineer

Devoted to the
Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories







Allis-Chalmers Type "AR" Induction Motors in the Wood-working Industry

The Type "AR" Squirrel Cage Induction Motor is used in a great number of wood-working plants throughout the country.

The all-steel frame construction makes it a very rigid and strong motor, eliminating breaking of feet.

Free and open ventilating passages provide good ventilation and make the motor accessible for cleaning.

Large rigid shafts with ample size bearings reduce bearing troubles to a minimum.

ALLIS-CHALMERS PRODUCTS
Electrical Machinery
Steam Turbines
Steam Engines
Gas and Oil Engines
Hydraulic Turbines
Crushing and Cement Machinery
Mining Machinery

ALLIS-CHALMERS MANUFACTURING COMPANY

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ALLIS-CHALMERS PRODUCTS
Flour and Saw Mill Machinery
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Pumping Engines-Centrifugal Pumps
Steam and Electric Hoists
Air Compressors - Air Brakes
Agricultural Machinery
Condensers

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 82 Chicago, November, 1924 *Number 11*

Good Service Is Worth the Price—

On the Other Hand, Indifferent or Poor Service from Men or Machines Breeds Trouble, Spoils Dispositions, Disrupts Things in General and is Expensive at Any Price

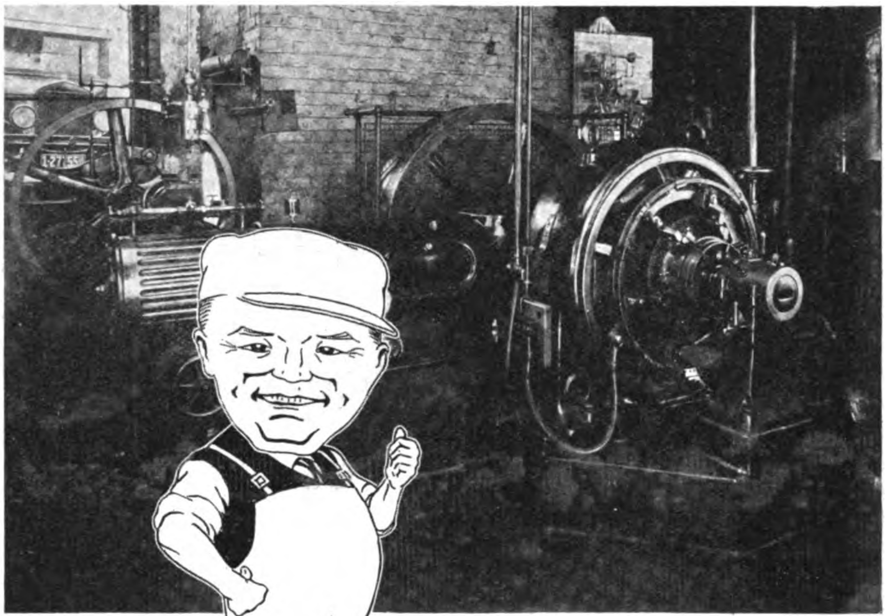
DURING the past year or so I have been able with the help of some old-timers who remember the kind of service first invaded by a motor and had a hand in this work, to give on this page some interesting examples of what seem to me to be two very important truths.

First, a good piece of apparatus like a motor that can tell a story of service without expensive repairs for eighteen or twenty years, is cheap at the top price that is asked for it. One which falls short of half this measure of service is expensive at any price.

Second, that motors have been built better than the designers really knew and details of correct installation are now more important than new refinements in design which, if needed at all, must usually be justified by competition in meeting a lower price.

Motors are bought to use and not to repair, so that service after all is the proof of good design, good workmanship and a fair price. Records of a few cases that measure up to these standards have been given on this page in past issues of INDUSTRIAL ENGINEER.

The accompanying photograph tells another interesting story of service from two Westinghouse generators, each rated 150 kw., operated at 220 volts, and direct-connected to Ball high-speed engines. These generators were installed in the Chamberlain Hotel in Des Moines, Iowa, in 1904 and have since furnished light for the building and power for operating elevators and other equipment. These machines are still in fine condition and good for some years to come. In checking up the service on these machines, Dr. E. S. Chamberlain, President of the Chamberlain Medicine Company at Des Moines, has written me as follows:



> This is in reply to your favor of September 26. In January, 1904 I purchased two 150-kw. Westinghouse generators direct from the Westinghouse Company at Pittsburgh, Pa., and also two Ball engines direct from the Ball Engine Company at Erie, Pa. These were installed in the Chamberlain Hotel and I believe they have been in constant use ever since. I know they did excellent work while I was connected with the hotel and for ten years after, while W. L. Brown was in charge.

C. H. Hartnagle, present manager of the Chamberlain Hotel at Des Moines, has written me as follows about this equipment:

> During the past ten years the only repairs that have been made to our engine-driven, Westinghouse generators have been turning of the commutator of one of them and replacing the eccentric on one engine. During this period there have been four different chief engineers in charge of our plant, and previous to that time there were two others who operated the plant from the time it was installed. The equipment at this time is in very good condition. The windings and insulation are apparently as good as new. We believe that the reason for the good service we have had is because the equipment was very good and that it has been operated and kept up by good engineers.

To be sure, some of the early designs shown are now relics, but their service furnishes practical information on which theorists can theorize some more on motor depreciation and what may be expected as a satisfactory useful life.

Practical Pete

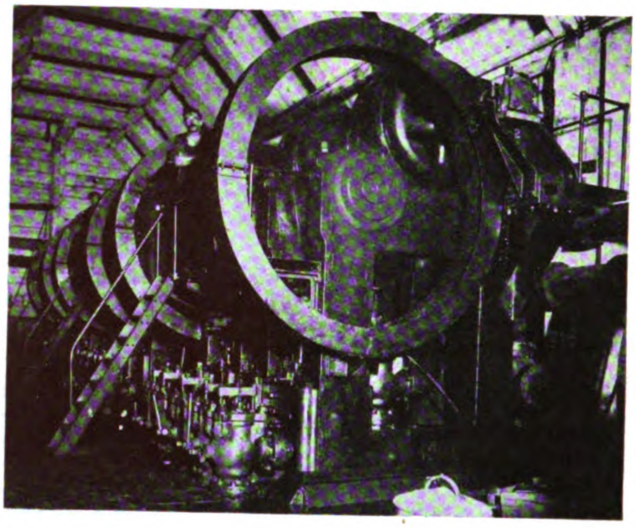
A Glimpse into the Works of the

Anaconda Copper Mining Company

Which mines, smelts and refines copper ore, producing forty million pounds of electrolytic copper monthly, and through its manufacturing organization, The American Brass Company, produces copper and copper-alloy materials and shapes

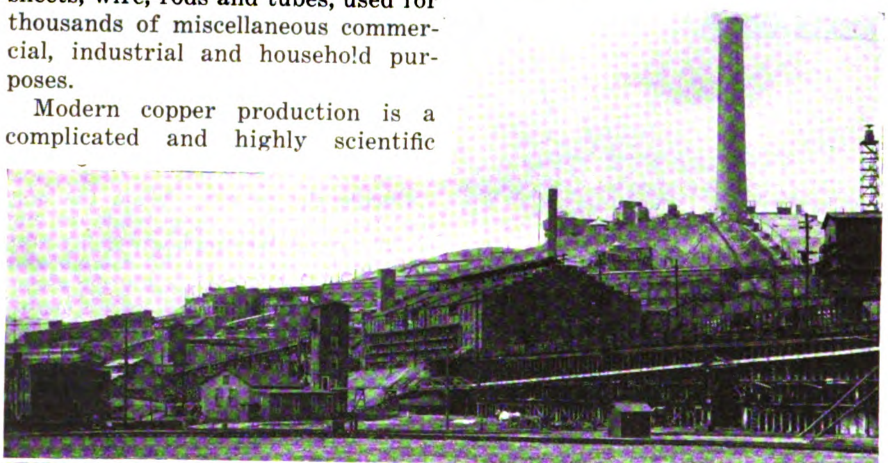
THE United States is producing 60 per cent of the world's output of copper and consumed in 1923 over 1,500,000,000 lb. or more than 75 per cent of all copper mined.

The Anaconda Copper Mining Company has, through its association with The American Brass Company, established for the first time a unified service from copper mine to the ultimate consumer of copper products. One organization is responsible for every operation—from the time the ore is extracted from the earth and converted into virgin metal until it is wrought into a wide variety of copper, brass, bronze and nickel silver products, in the form of sheets, wire, rods and tubes, used for thousands of miscellaneous commercial, industrial and household purposes.

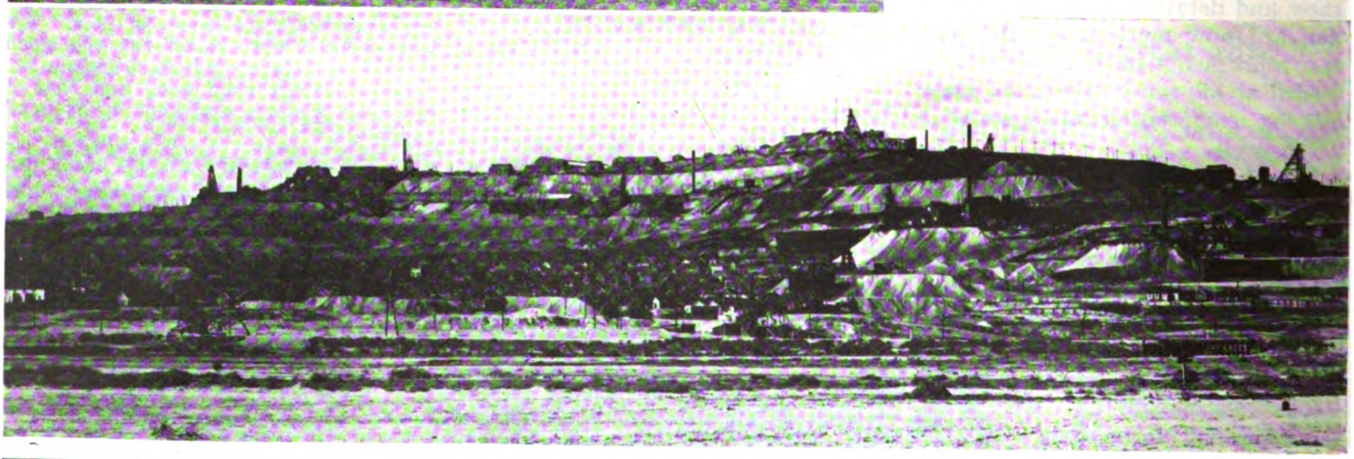


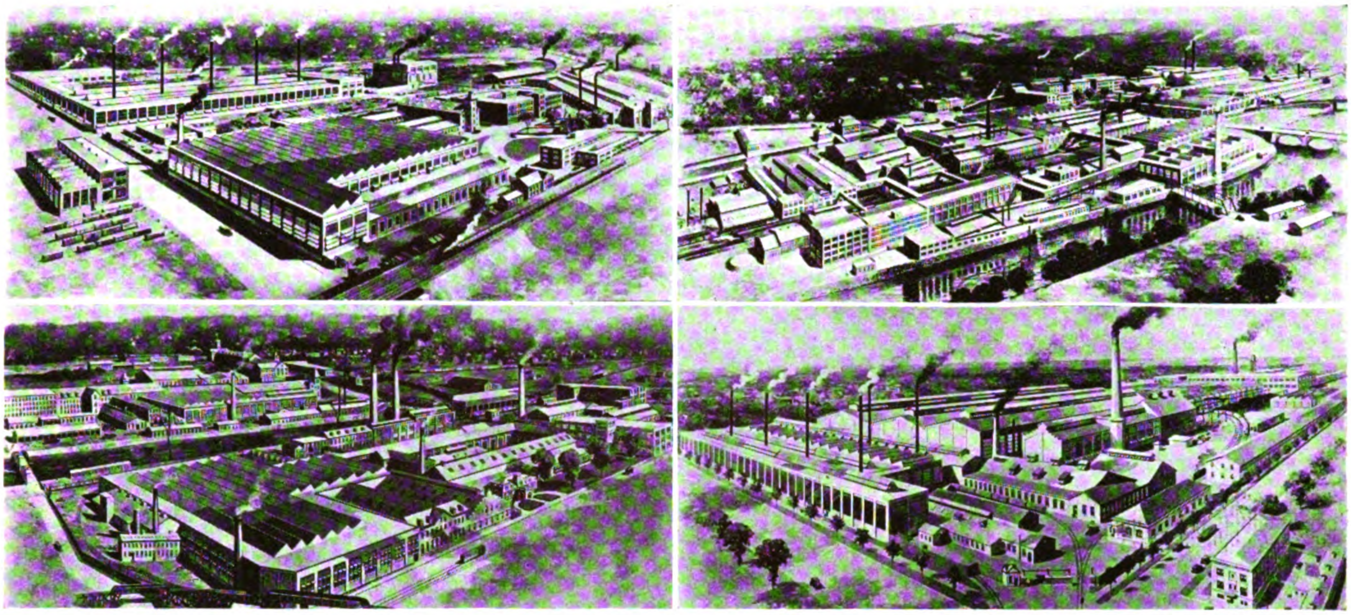
One of the big problems is pumping water from the mines. This shows a battery of quintuplex vertical electric pumps with a capacity of 600 gal. per min., under a head of 1,200 ft. Each pump is direct connected to two 150-hp., 2,300-volt motors. These pumps are operated underground at High Ore Mine, Butte, Mont.

Modern copper production is a complicated and highly scientific process. The mining operation yields ore which then undergoes a variety of treatments, such as concentration, roasting, smelting and converting, and finally emerges in metallic form. Some idea of the size of Anaconda operations in Montana is obtained from the fact that during the past forty years the Anaconda Copper Mining Company has produced there a total of 100,000,000 tons of copper ore, which would fill a train 13,000 miles long. The copper content of this amounted to over 4,000,000 tons or 4 per cent of the ore mined. If it were all drawn into copper wire, such as is used in telegraph or telephone lines, this copper would reach 50,000,000 miles.



About 90 per cent of all copper consumed in the United States last year was refined by the electrolytic process, which produces pure, high-conductivity copper. All Anaconda copper is electrolytically refined, either at Great Falls, Mont., or at Perth Amboy, N. J., adjacent to New York harbor. The plant at Perth Amboy is one of the largest electrolytic copper refineries in the world, covering an area of forty acres and having refining capacity of about





Four of the manufacturing plants of The American Brass Co.

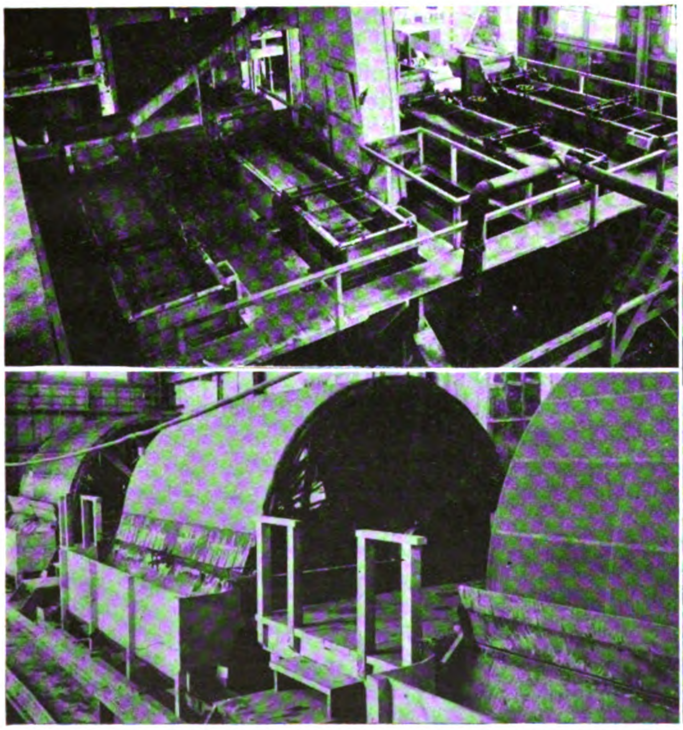
The two plants at the left are located at Waterbury, Conn., the main office of The American Brass Company. The two at the right are at Ansonia, Conn. (top) and Kenosha, Wis. This company is the world's largest manufacturer of copper and copper alloys in the form of sheets, wire, rods, tubes and special shapes. The seven plants located near the industrial centers turn out in excess of 600,000,000 lb. annually.

40,000,000 lb. of copper monthly.

The American Brass Company, with headquarters at Waterbury, Conn., is the world's largest manufacturer of copper and all combinations of copper, zinc, lead, tin and nickel, which can be wrought in the form of sheets, wire, rods, tubes and special shapes. The Anaconda Copper Mining Company also operates a rod and wire mill with a capacity of 125,000,000 lb. per year, at Great Falls, Mont.

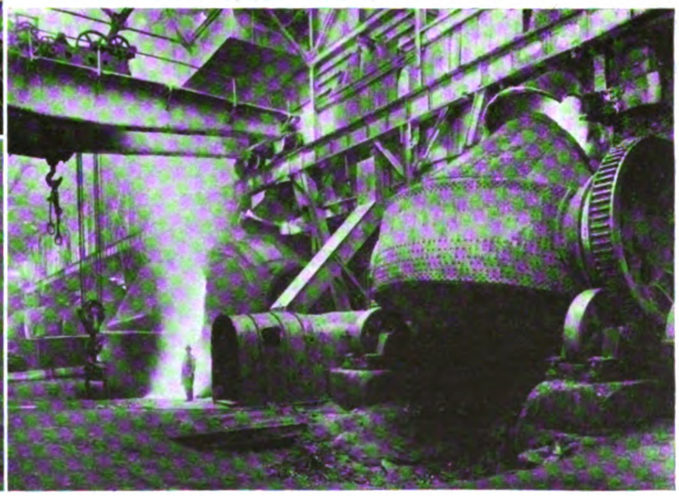
The growth of the electrical industry is, in part, responsible for the greatly increased use of copper. This industry now accounts for about 60 per cent of the total domestic copper consumption, or about 900,000,000 lb. a year. Hydro-electric development now under way promises to add greatly to the electrical industry's consumption of copper, for each kilowatt of energy developed requires approximately 8 lb. of copper.

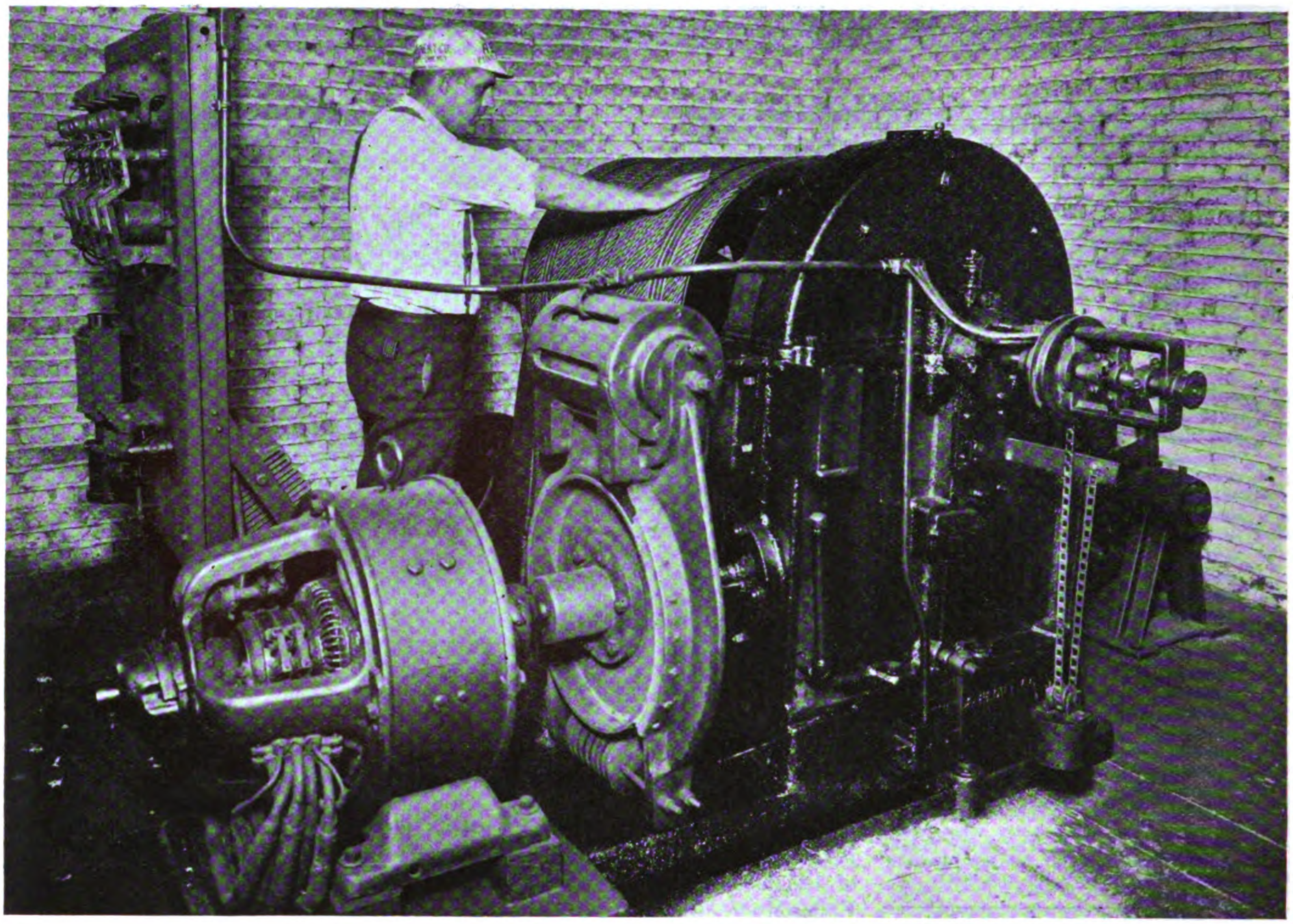
Copper, brass and bronze come into numberless uses in building, as hardware fixtures, as wire, and as screening; (*Continued on page 556*)



Three important steps in the smelting of copper.

Much of the ore has to have the sulphur roasted out of it first. The ore is then ground and washed in Hancock jigs (upper left) which concentrate the ore. The illustrations in the lower left corner show the Oliver filters for removing the water from the concentrate, before smelting. In the converting process (below) 65-ton charges of molten matter with a copper content of from 40 to 50 per cent have air under pressure of 16 lb. per sq. in. blown through the liquid mass to burn off the remaining sulphur and slag the iron. In addition to copper, gold and silver in small amounts are also recovered from the ores.





The inspector shown here is finishing up his work on the elevator machine by watching and feeling the cables for broken wires and other defects.

Details of Procedure in

Repairing and Rebuilding Electric Elevators

With the Routine Followed and Order Forms Used in Sending the Work Through the Shop and Keeping a Permanent Record of Each Job

By R. H. KUEHMSTED
Vice President, Thompson and Jameson, Inc., Chicago, Illinois

ELEVATOR repair work is in most cases an emergency job and must be handled as such. Contrary to the general opinion, elevator accidents such as the car falling, cables breaking and so on, are seldom fatal, so far as human life is concerned, because modern safety appliances are so efficient that danger of serious injury to the operator or passengers has been reduced to a minimum. However, elevators are used so widely for carrying both passengers and freight that any failure of this mode of transportation may, and usually does, result in a great deal of inconvenience or a serious delay in production. In any event it is a situation which must be cleared up as quickly as possible in order that service may be restored with the least possible delay.

For many years we have specialized in the installation and repair of electric elevators and inasmuch as this means that our plant must be so organized that all of the work which comes in can be scheduled and handled with the utmost despatch, with each department doing its job at the proper time, an account of our methods and the routine followed may be of interest. In addition to the elevator work mentioned above, we do a large amount of business in the repair of motors and starting equipment, and the sale and rental of used motors.

There are approximately fifty different makes of electric elevators in use. These are made in various designs and sizes, so that an attempt to carry in stock a complete set of replacement parts would result in tying up a large amount of capital and space. Further, many elevators now in use are either obsolete types or were made by firms which have gone out of business, so that it is very difficult or impossible to obtain spare parts. For these reasons we find that in many cases we must make new parts, as we can not buy them, although we do carry large stocks of certain parts. Our machine shop is, consequently, well equipped with all of the machine tools needed to turn out promptly any new parts

that may be needed. The machine shop is close to the shipping department and both are served by several chain hoists running on overhead I-beams, so that the heaviest parts or machines can easily be handled from one machine to another, or between departments. A portion of the machine shop is shown in Fig. 1.

The motor repair, controller and other departments are likewise thoroughly equipped with coil-winding and taping machines, dipping tanks, baking ovens, testing apparatus and other devices for repairing or rebuilding any equipment of this nature. Fig. 3 shows a section of the coil-winding department.

Routine Method of Handling Elevator Repairs

Considering for the moment the elevator repair division of our business, when a trouble call comes in, usually over the telephone, the person who takes the message fills out the form shown in Fig 2 *A*. This form is made out in duplicate, white and blue. When the data is complete, the blue copy is filed and the white copy is given to the salesman in that territory. Incidentally, this form is used for inquiries of every nature, including the sale or repair of motors or other equipment, and so on.

If the customer waives the formality of an estimate, as is frequently the case, an order form, Fig. 2 *H*, covering the work required, is made out.

In either event an inspector is then sent at once to the plant or building where the defective elevator is located. He makes a thorough examination to determine the nature and extent of the repairs needed. These may vary from the replacement of a small part or minor adjustment, to practically rebuilding the winding machine, rewinding the motor or completely overhauling the control. If an estimate is required, the results of this inspection are entered on the form in Fig. 2 *A*, for our records.

A written proposal is then immediately drawn up in the form shown in Fig. 2 *B*, and submitted to the customer. As will be noted this proposal completely covers the transaction, including the work to be done, material to be furnished and price and terms of payment. This proposal is, of course, made out in duplicate; one copy goes to the customer and one is placed in our files.

TRANSPORTATION of both passengers and freight by means of elevators is such an important factor in the operation of modern industrial plants that any interruption of this service is attended by serious delays and inconvenience. When such interruptions do occur it is usually imperative that the cause of the trouble be located and the necessary repairs made as soon as possible. In this article Mr. Kuehmsted describes the order systems used, shop routine followed and records kept by an organization which has for many years specialized in the installation, repair and maintenance of all types of electric elevators.

If an estimate has been requested, we wait until the customer accepts the proposal; otherwise work is immediately started on the job. If it is necessary to dismantle any part of the elevator mechanism and take it to the shop for repairs, this is done.

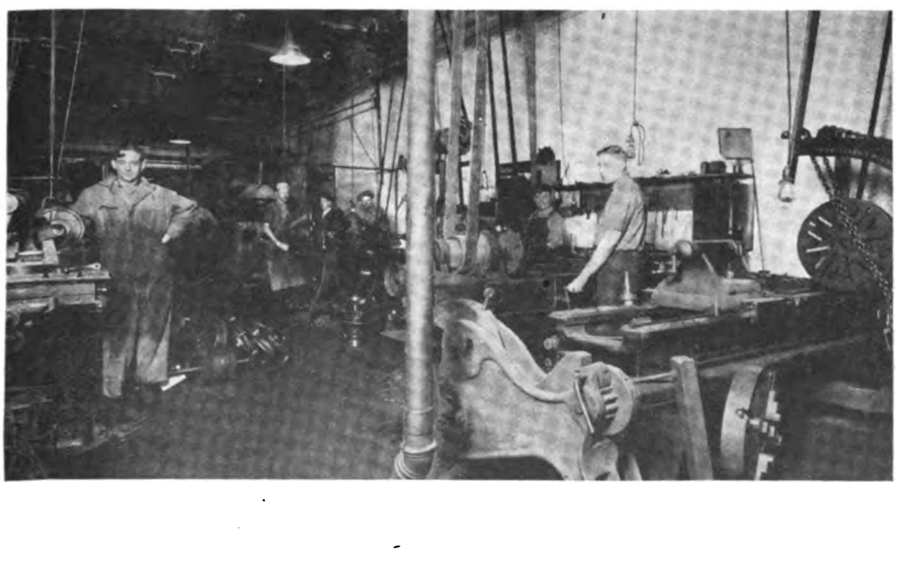
When a badly worn or broken machine or part is sent in from a job the first step is to attach to it the Repair Tag, shown in Fig. 5. This tag is made out in duplicate, a heavy yellow sheet which is wired or tied to the part, and a white Inspection Report, both of which bear the job number. The part is inspected by the foreman or an inspector and the nature of the repairs noted and the report O. K.'d by the foreman or superintendent. The white Inspection Report is held in the *Inspection Department* until the repairs are complete and the part ready for final inspection before shipment. The tag and sheet are then returned to the office and filed.

Drawings are then prepared, if needed, and the work sent to the machine shop. Here the necessary work is done and the new or repaired part is sent back to the job, after careful inspection and checking. The machine shop foreman records on the Machine Shop Record of Material and Operation Sheet, shown in Fig. 2 *G*, the material used, nature of operations and time required for the job. This sheet is then sent to the office where it is filed under the job number until all of the time and material tickets have been turned in.

Perhaps the motor driving the winding machine needs rewinding or overhauling. If so, it is sent to the motor repair department in our shop. Here it is examined carefully and the repairs necessary to put it in first-class condition are noted. If the armature has to be rewound, say, the foreman makes out the Armature Data and Coil Data cards shown in Figs. 2 *C* and 2 *F*, which give all of the winding data, with the job number. The Coil Data card is then sent to the coil winder for his guidance in making the coils. When these have been properly varnished and baked they are inserted in the armature or rotor in accordance with the data given on the Armature Data card. In many cases coils are laid first and dipped and baked after the armature or stator has been re-

Fig. 1—Part of the machine shop in which repairs to elevator equipment are made.

Because it is difficult or impossible to obtain replacement parts for many old-type or obsolete elevators, this machine shop is equipped to make any new part that may be needed, as well as perform any operations necessary in repairing or reconditioning worn parts. All machine work on motors, such as turning commutators, fitting new bearings, and the like, is also done here.



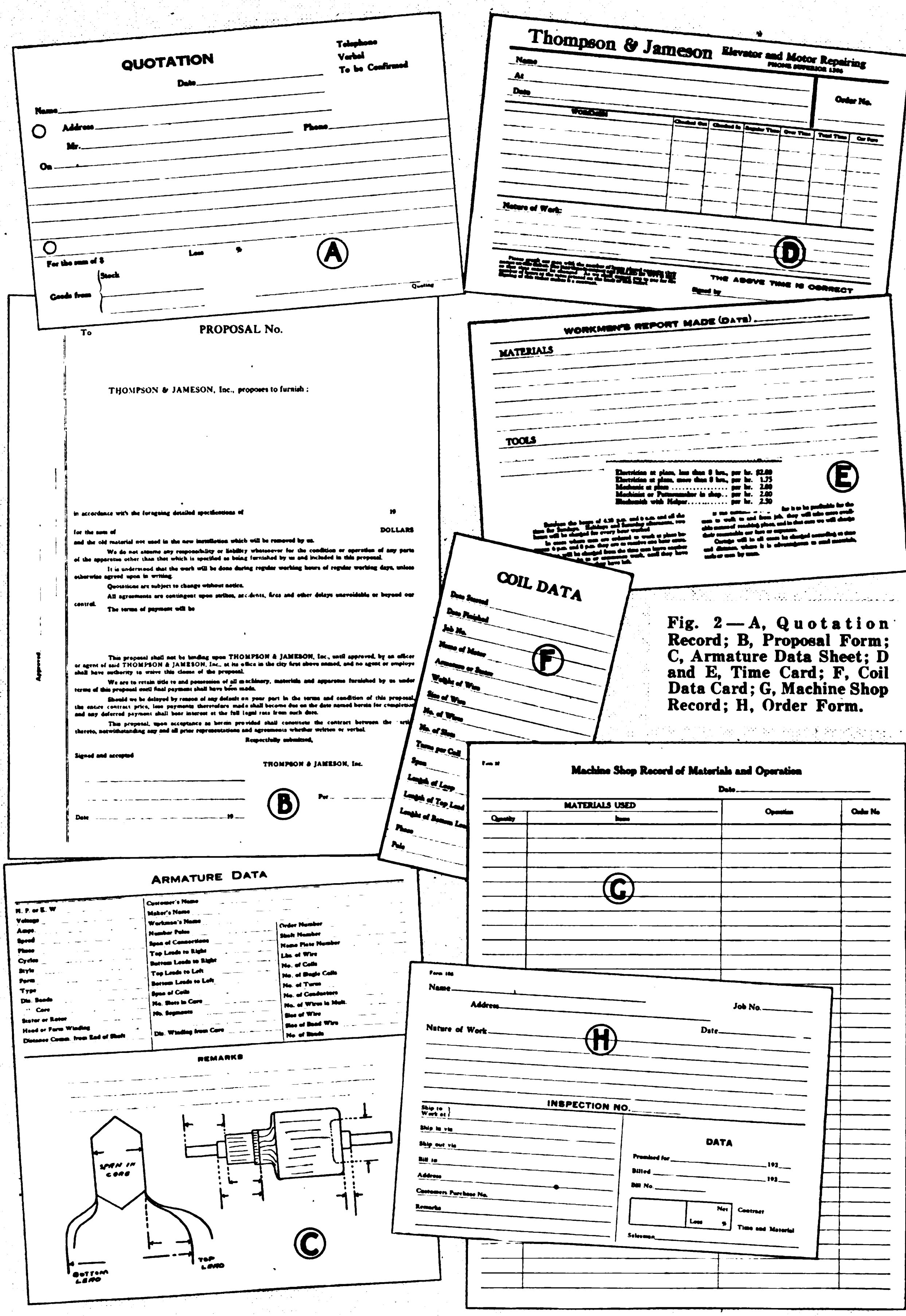


Fig. 2—A, Quotation Record; B, Proposal Form; C, Armature Data Sheet; D and E, Time Card; F, Coil Data Card; G, Machine Shop Record; H, Order Form.

wound. After the job is completed and the motor has satisfactorily passed the inspection tests, the cards are turned in to the office where they are filed under the proper job number.

The men who are working on the outside, for example overhauling or repairing an elevator, record their time on the tickets shown in Fig. 2 *D;* the back of these tickets is shown in Fig. 2 *E*. As will be noted, the customer is required to certify to the amount of time spent by our workmen while in the customer's plant. This not only gives us a check on our own men, but it precludes any possibility of dispute as to the number of hours spent on the job, a situation which is always unpleasant for everyone concerned.

The men in the shop enter their time on the ordinary form of job card, in which spaces are provided for entering the name of the workman, the date, job number, rate of pay, and time spent on each job.

When the shop work on, say, an elevator repair job is completed, the repaired parts are taken to the customer's premises and installed again. After the job is completed and the elevator has been turned over to the customer in satisfactory operating condition, all of the time and material tickets previously mentioned are turned in to the office where they are filed under the job number. The summary sheet shown in Fig. 6 is then made out from the data contained on the different tickets. This summary sheet shows, among other items, the nature of the work, the time spent by our workmen at the customer's plant and in our shop, the nature and amount of material used, and the profit or loss to us, on the job. This sheet is filed under the customer's name and furnishes a complete record of the whole transaction, so that if any question comes up later on, or we desire to know what was done and how much profit was made or loss incurred on a certain job, we have the information available at a moment's notice. These summary sheets are, of course, of the utmost value in helping us to prepare estimates of the cost of repair and other work.

Elevator Maintenance Service Insures Thorough Inspection

A very large percentage of the interruptions to elevator service result more or less directly from accidents due to carelessness, or neglect of the equipment. Lubrication of bearings and moving parts may be improperly done, at long intervals, or not at all. Bearings may be allowed to wear out without renewal at the proper time. Contacts may be allowed to arc and burn until little or nothing is left of them. In short, the equipment may be allowed to run as it will, with little or no attention, until some important part wears out or breaks and the whole machine is put out of commission; then an expensive repair or overhauling job may be required before service can be restored.

In plants or buildings where the amount of machinery in operation does not warrant hiring a competent maintenance man to take care of it the question of electric elevator maintenance is troublesome. The owner is confronted with the problem of either paying a stiff price for his elevator maintenance or else letting his equipment operate with little or no attention, but with the prospect of expensive interruptions to service and large repair bills, all of which may be still more costly in the long run. Usually one serious breakdown is enough to convince the owner that there is no economy in neglecting his equipment.

The logical solution of this problem is elevator maintenance service, which is an important part of our business. We employ a staff of men who are experienced in all branches of elevator maintenance and repair work and whose services are available to anyone who needs them. This service is furnished on the basis of a contract whose form is shown in Fig. 4 *E*. This form is, of course, made out in duplicate, one copy for our files and one for the customer. The terms of this contract are not at all burdensome; in fact it is nothing more than a written agreement between us and the customer whereby we agree to furnish certain services for a specified sum of money. The amount charged for this service varies according to the conditions, such as number and type of elevators, location in the building, height of building and the like. The frequency of inspection is likewise an important factor affecting the price. As a general statement, the contract price of our elevator inspection service varies from about $4 to $15 per elevator, according to the conditions and number of times inspected per month.

The contract is practically on a month-to-month basis, as it can be terminated by a written notice at any time by either party, although we reserve the right to complete the full month of service.

The contract specifies that a certain number of inspections of each elevator shall be made each month. This number also varies according to conditions: an electric elevator installed in a clean, dry place and where the conditions of service are not severe plainly does not require the same amount of attention that should be given to an installation in a very damp or dirty place and operated perhaps twenty-four hours a day. All of these points are taken into consideration when the contract is made and we use our own judgment, based on long experience, as

Fig. 3—The coil-winding section of the motor repair shop.

This department is equipped with coil-winding and taping machines, some of which are not shown here, capable of handling any size of armature, field, or stator coils likely to be encountered. The varnish dipping and baking equipment, which is designed to take complete stators and armatures or rotors, is located on the other side of the brick wall at the left.

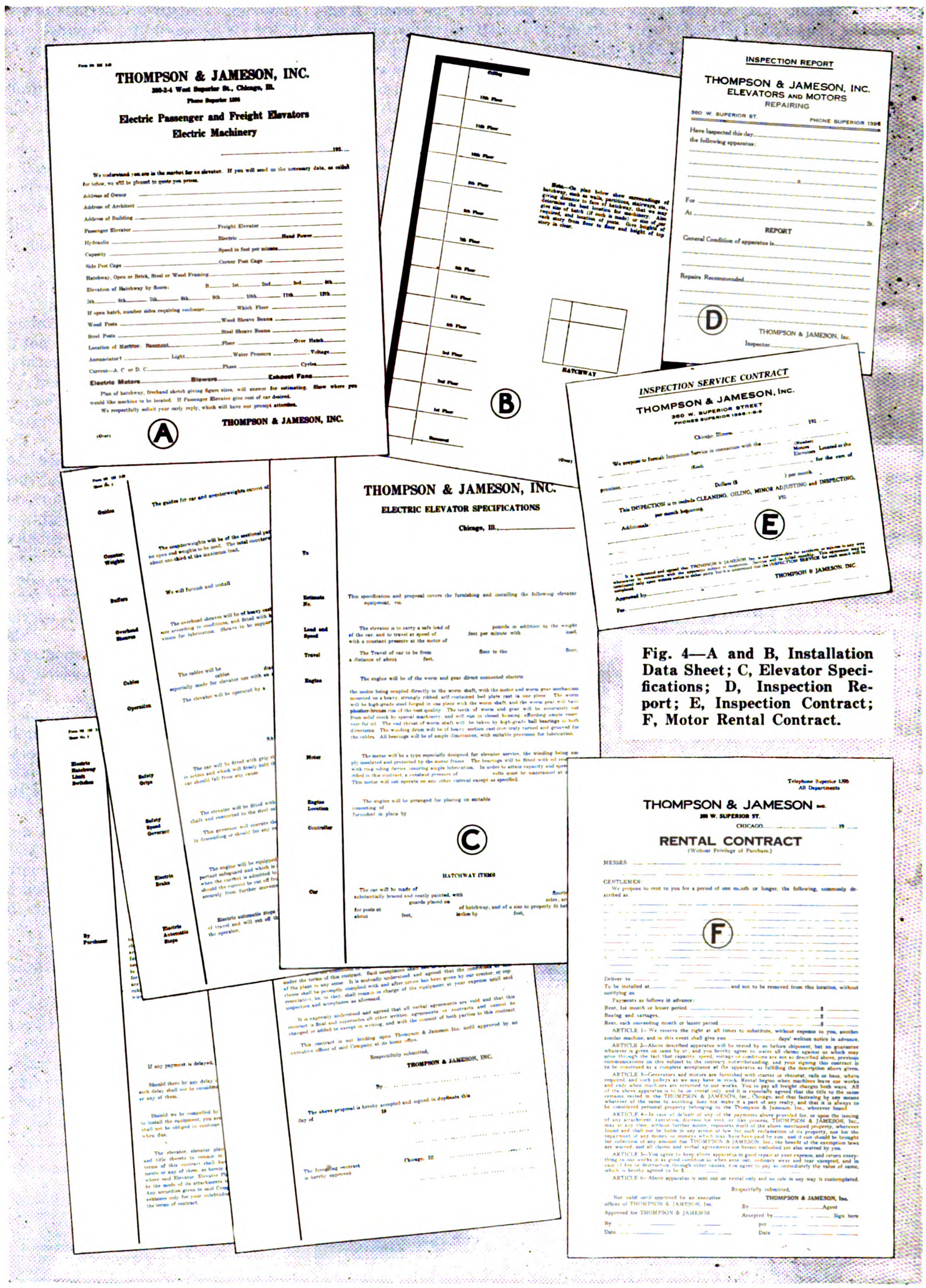


Fig. 4—A and B, Installation Data Sheet; C, Elevator Specifications; D, Inspection Report; E, Inspection Contract; F, Motor Rental Contract.

to the frequency of inspection. As a rule, inspections are made at least once a month and usually not more than four times a month.

Inasmuch as we service many different makes and designs of electric elevators it is not practicable, or necessary, to specify in the contract all of the operations which are included under the head of inspection. These are lumped as cleaning, oiling, minor adjustments and inspection. As a matter of fact, however, our inspection may be briefly outlined as follows:

The motor is inspected first; this inspection consists in examining the commutator, brushes, brush holders and bearings, in a direct-current machine. In the case of an alternating-current motor, the bearings are inspected, the oil level noted, and the air gap between rotor and stator is checked. This is done by inserting in the air gap a flat piece of steel which is about No. 22 gauge, for general use.

Next the controller is inspected to see that all contacts are in good condition and all connections tight. The acceleration is tested to make sure that it is properly timed. All working parts are well oiled.

The elevator engine is then examined. The worm and drum bearings are tested to see that they are in good condition and properly lubricated. All bearings are oiled and the stuffing box on the worm shaft is looked over to see that it does not leak oil. The spokes in the drum are carefully gone over to see that

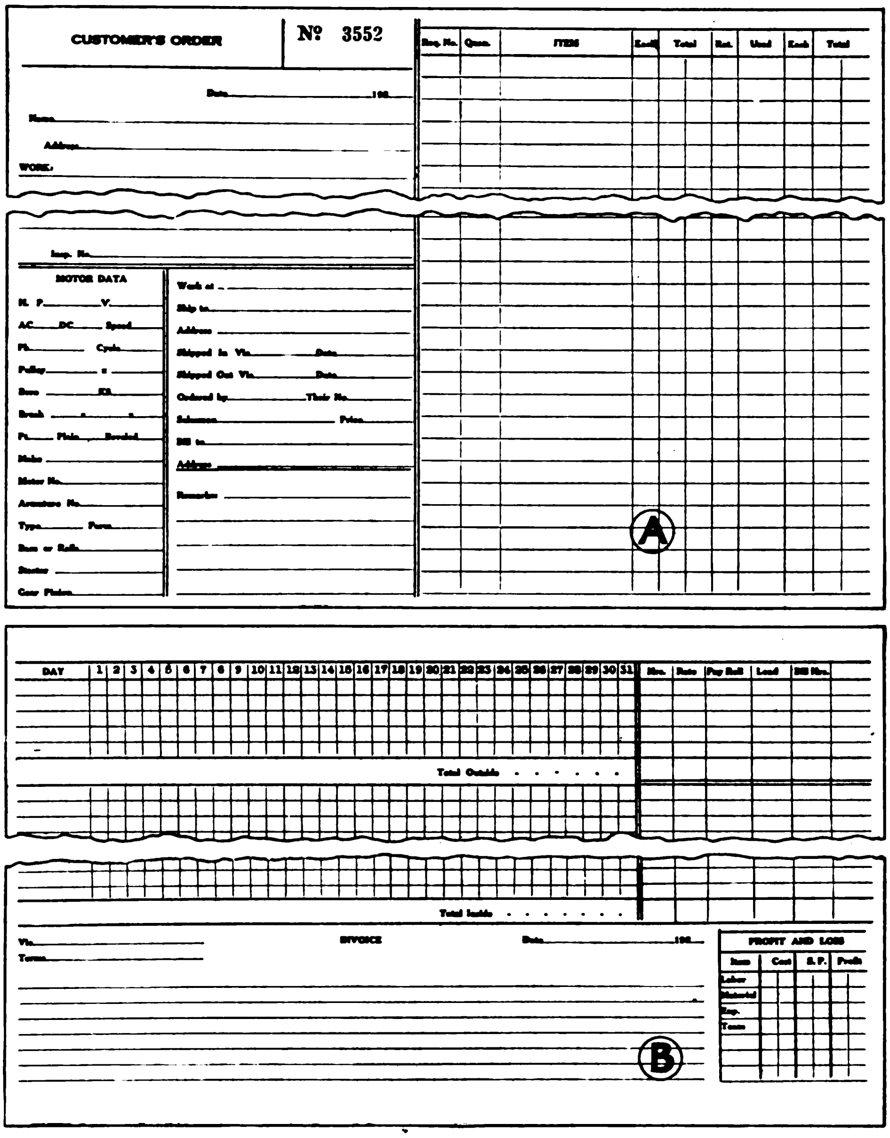


Fig. 6—This summary sheet contains a complete record of every repair job.
When all of the time and material tickets and other records pertaining to a job have been turned in to the office this form is made out. It shows all of the data, including the profit or loss, that is likely to be required for purposes of record. This sheet is filed under the customer's name.

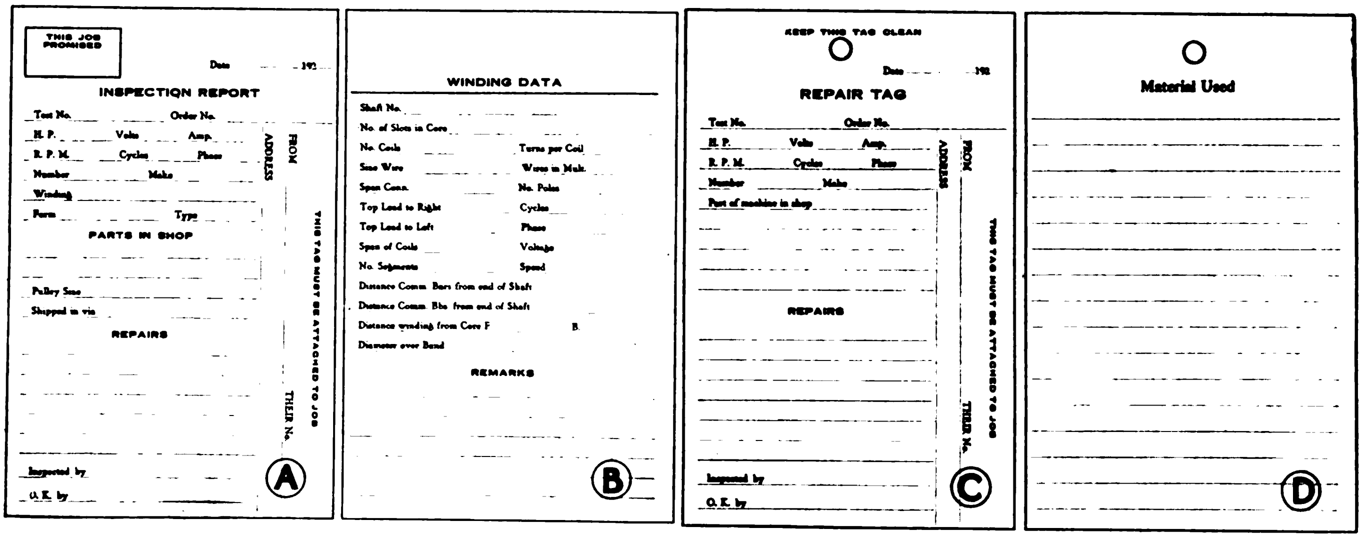
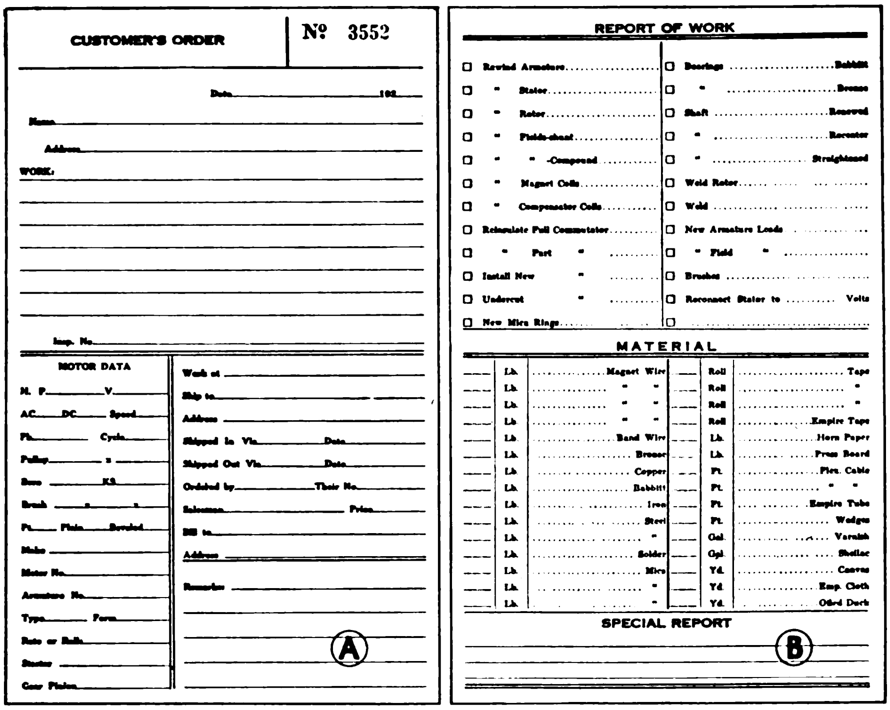


Fig. 5—These Inspection Report and Repair Tags serve to identify every job which comes into the shop.
A and *B* show the front and back, respectively, of the Inspection Report, while *C* and *D* show the front and back of the Repair Tag. When a motor or other part comes in for repairs these tags are attached to it and the part sent to the *Inspection Department.* Here the part is examined and the nature of the repairs noted on the Repair Tag. The inspector detaches the Inspection Report and holds it until the repairs have been made and the part returned for inspection and checking. When the part has been passed as satisfactory by the *Inspection Department*, these tags are sent to the office and filed under the job number.



CUSTOMER'S ORDER No. 3552

Date ________ 192__

Name ________

Address ________

WORK:

Insp. No. ________

MOTOR DATA

H. P. ____ V. ____
AC ____ DC ____ Speed ____
Ph. ____ Cycle ____
Pulley ____ x ____
Bore ____ KS ____
Brush ____ x ____ x ____
Pt. ____ Plain ____ Beveled ____
Make ____
Motor No. ____
Armature No. ____
Type ____ Form ____
Rate or Balls ____
Starter ____
Gear Pinion ____

Work at ____
Ship to ____
Address ____
Shipped In Via ____ Date ____
Shipped Out Via ____ Date ____
Ordered by ____ Their No. ____
Salesman ____ Price ____
Bill to ____
Address ____
Remarks ____

(A)

REPORT OF WORK

☐ Rewind Armature	☐ Bearings .... Babbitt
☐ " Stator	☐ " .... Bronze
☐ " Rotor	☐ Shaft .... Renewed
☐ " Fields-shunt	☐ " .... Recenter
☐ " " -Compound	☐ " .... Straightened
☐ " Magnet Coils	☐ Weld Rotor
☐ " Compensator Coils	☐ Weld
☐ Reinsulate Full Commutator	☐ New Armature Leads
☐ " Part "	☐ " Field "
☐ Install New "	☐ Brushes
☐ Undercut "	☐ Reconnect Stator to .... Volts
☐ New Mica Rings	☐

MATERIAL

____	Lb.	Magnet Wire	____	Roll	Tape
____	Lb.	" "	____	Roll	"
____	Lb.	" "	____	Roll	"
____	Lb.	" "	____	Roll	Empire Tape
____	Lb.	Band Wire	____	Lb.	Horn Paper
____	Lb.	Bronze	____	Lb.	Press Board
____	Lb.	Copper	____	Ft.	Flex. Cable
____	Lb.	Babbitt	____	Ft.	" "
____	Lb.	Iron	____	Ft.	Empire Tube
____	Lb.	Steel	____	Ft.	Wedges
____	Lb.	"	____	Gal.	Varnish
____	Lb.	Solder	____	Gal.	Shellac
____	Lb.	Mica	____	Yd.	Canvas
____	Lb.	"	____	Yd.	Emp. Cloth
____	Lb.	"	____	Yd.	Oiled Duck

SPECIAL REPORT

(B)

Fig. 7—The operations performed and material used on a motor repair job are shown on this report. *A* shows the front of the report, while the back is shown at *B*. This form is used for obtaining the cost of motor repair jobs and is afterwards filed under the job number as a permanent record. With the help of such records the cost of a repair job can be estimated very closely.

none of them is cracked. The keys in the drum shaft are inspected to make sure that they are tight.

The sheaves and idlers are next inspected to determine whether any of the journal boxes are worn or the spokes cracked. The bearings are lubricated.

Every foot of the cables is carefully examined for broken wires or bad spots and well oiled, if necessary. Cables in damp places usually are kept lubricated.

The guides for both the car and the counterweight are then inspected to see that they are properly lined up and firmly fastened. Also, they are well greased.

The car then receives attention. All bolts are looked over to make sure that they are tight; the shoes on the car are examined to see if they have the proper amount of play on the guide rails, the safety devices are carefully examined and tested and the governor inspected and oiled. Finally, the elevator is operated to see that everything, including the limit switches, works properly.

After each inspection a written report is rendered to the customer on the form shown in Fig. 4 *D*. This report, which is made out in duplicate, one copy going to the customer and the other to our files, shows what the condition of the equipment is and if any repairs are needed describes them briefly. The owner then decides whether he wishes to have these repairs made. We do not, of course, do any actual repair work without the written authorization of the owner. However, the customer usually accepts our recommendations and gives us an order to do the work, which is then handled in both the shop and the office in the manner previously described.

Incidentally, the fact that we have a number of men who spend most of their time on elevator inspection work makes it possible for us to put on an emergency job any number of men that may be needed.

Routine for Installation of New Elevators

The sale and installation of new elevators is another important part of our business. When we locate a prospective customer who is, or is likely to be in the market for an elevator installation, we send him the data sheet shown in Fig. 4 *A*; the back of this sheet is shown in Fig. 4 *B*. This data sheet may be of interest to the readers of Industrial Engineer as it indicates the information which is ordinarily required before an elevator can be installed, or an estimate of the cost given.

When this sheet is returned properly filled out, we send an engineer to look over the ground and secure such additional information as may be desired. A specification, in the form shown in Fig. 4 *C*, is drawn up and submitted to the prospective customer. This specification covers all of the details of an installation including the duties and responsibilities of the customer, as well as our own, and gives the price and terms. In the event that our proposition is accepted, a job number is assigned for the installation and all time and material tickets and the like are charged to this number. When the job is completed these tickets are filed under the job number and a summary sheet, Fig. 6, is made out and likewise filed, so that we have on one sheet a complete record of the job, including the amount of profit or loss.

Although it was not the intention, when this company was first organized, to engage in the commercial repair of motors we were finally forced to do this. In order to take care of our elevator business properly, it was necessary to have a well-equipped motor repair shop, with experienced winders and other repair men who were capable of handling quickly and efficiently any burned-out or damaged motor which we would be called upon to repair. Burn-outs of elevator motors are not of such frequent occurrence that we could keep the motor repair department busy all of the time. In consequence, it was decided to extend our activities to include the repairing of motors or generators for anyone who wished to have such work done.

When a motor is sent in for repairs a Repair Tag, Fig. 5, bearing the job number, is attached to it and the motor given a thorough examination to determine just what is needed to put it in good condition. If it is a rewind job the foreman makes out the Armature Data and Coil Data cards, shown in Figs. 2 *C* and 2 *F*. As was mentioned above, these are given to the winder and after the job is completed are sent to the office where they are filed under the job number. In addition, the foreman checks off on the form shown in Fig. 7 all of the operations which are performed on the motor or generator and notes the amount of wire, tape, solder, insulating material and the like used for the job. This sheet is likewise sent to the office and filed. We are thus enabled to keep very accurate costs on all repair jobs, so that these sheets are very useful in helping us to estimate the cost of repair work.

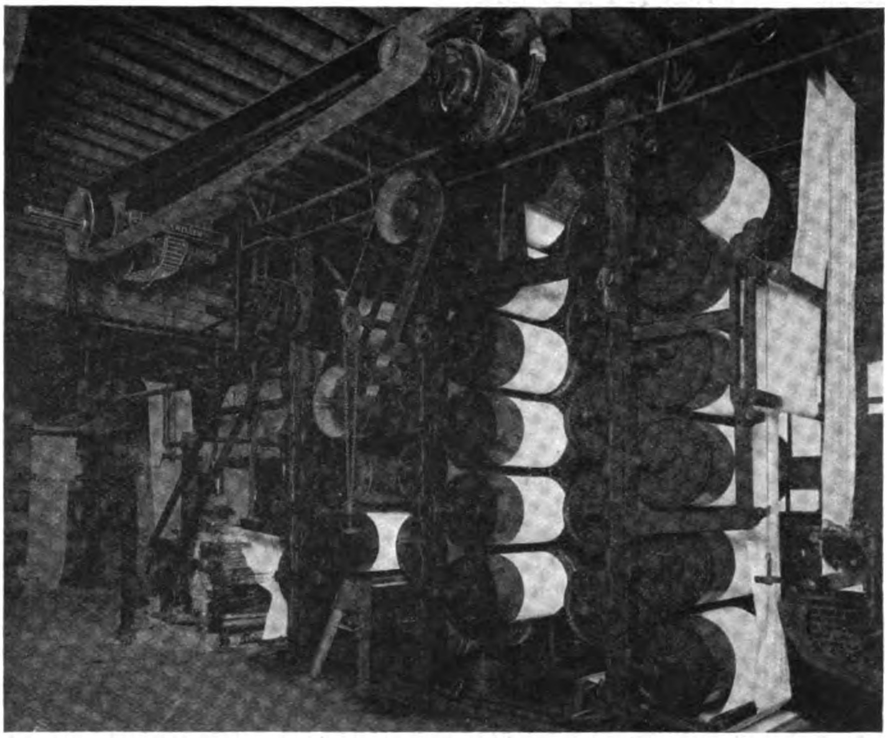
The development of our business in the sale (*Continued on page 553*)

Some Practical Pointers on

How Variable Speeds Can Be Obtained

For Adjusting the Speed to the Needs of a Process or to Work Performed by Machines Singly or in Groups in Industrial Plants

By FRANK E. GOODING
Associate Editor, Industrial Engineer



Mechanical variable speed transmission with automatic control operating dryers and starch rolls at the Rockland Bleach and Dye Works.

PRACTICALLY all production machinery may be operated to advantage at more than one speed. Many machines, however, could well be operated at a number of different speeds, particularly where different kinds of work are done on the same machine, or the process requires various applications. One example of this is in "filling" cloth in some textile processes. Many grades of cloth are filled after weaving. Ordinarily, the machine is provided with a driving pulley which will give the proper speed for the work requiring the slowest speed. Lighter weight cloth can be handled faster, but unless the pulley is changed or some other means provided for changing the speed, light work goes through as slowly as the heavier. An increase in speed would give a greater production with a consequent lowered cost.

Many other industries offer similar advantageous opportunities to use variable speeds as will be explained in this article. Different operating speeds may ordinarily be obtained for machines by (*a*) variable speed transmission devices which give an infinite ratio of increments between a fixed maximum and minimum; (*b*) devices which give increment of speed in fixed steps, such as gear boxes, gear shifts, cone pulleys and most adjustable-speed motors. Variable-speed devices should not be confused with spur- or worm-gear speed reducers which give a constant speed ratio.

This second type gives what might be termed a number of selections of constant speed instead of a true variable speed. This article, however, will deal largely with the first type which gives a more truly variable speed. This group in turn may be divided into:

(1) V-belts or pulleys, the diameters of which may be varied.

(2) Two parallel cone-shaped pulleys connected by a belt which may be shifted along the cones.

(3) Special hydraulic transmissions which give any increment of speed from nothing up to the speed of the driving mechanism.

(4) Sliding friction disks.

(5) Various special and complicated mechanical devices made up of sliding links, gears and other mechanical movements which can be varied over a definite range.

Probably, the most common of these types is the first which is known as the variable-speed transmission unit. This has a V-belt operating on a pair of pulleys, each of which consists of two cone-shaped disks mounted with the points of the disk turned toward each other, the tips of the cones forming the center of the pulley. The V-belt rests in the V formed between the two cones. Provision is made whereby one set of cones may be moved closer together which makes the belt ride higher on the pulley formed between the cones, while at the same time the other set of disks are moved farther apart, which makes that end of the belt ride lower between the two cones. This increases the diameter of one pulley as it decreases the diameter of the other and thus it varies the speed of the driven shaft. One pulley is connected with the driving motor of fixed speed or to a shaft and the other transmits power to the driven mechanism at a variable speed.

These are made either with plain self-oiling bearings or ball bearings and in a range of sizes in capacity up to 150 hp. by one manufacturer and up to 75 hp. by another. They range from the speed variation of 1 to 1½ up to 1 to 16 and over a range of speed both above and below the initial driven speed. For example,

> WHERE OUTPUT depends upon the operating speed, variable-speed equipment enables the machinery to be driven at the best speed and also to be varied to suit conditions. For example, thin cloth can go through bleachers and driers more rapidly than can thicker material. Some of the factors in other industries which affect output by controlling the speed at which the work may be performed are: humidity, temperature, gage, quality and number of operators. How these may be compensated for by varying the speed is described in the accompanying article.

one size with a ratio of 1 to 10 variation is driven at 270 r.p.m. and will deliver any speed between 85 r.p.m. minimum and 850 r.p.m. maximum. All of these variations are not available in each of the sizes made, however. Sizes, ranges and capacities of these devices should be obtained from the manufacturer of any special equipment chosen. Higher ratios may be obtained by using combinations of more than one set of pulleys on both the driving and variable speed shafts. One such combination is shown in an accompanying illustration. It should be remembered, however, that the driving speed should not be greater than that recommended by the manufacturer. Otherwise, the load may go beyond the capacity of the equipment.

Variable-speed transmission units are used in a large variety of work. For example, they are often connected into the drive of an assembly conveyor in automobile factories to give a variable speed to its travel. Thus, if the output of cars is low for a certain day, fewer men, each with more work to do, are employed on the assembly line, and consequently the conveyor must move more slowly. If the production is to be increased, more men are put on the line and it is speeded up. Also, when beginning work in the morning, or after luncheon, the men start "cold" and require some time to get up to speed. After starting, the line may be speeded up a little at a time until it is finally up to full operating speed. The shifting mechanism may then be locked into position so that no unauthorized worker can slow it up. This enables the assembly line to be driven at all times at the best speed for the conditions, which may vary according to the quantity of output and also with different types or models. If the speed changes were not so easily made, much of this work would be done at a less effective speed.

In the Miller-Hurst power unit, which is used for driving assembly conveyors in a number of automobile plants, a constant-speed (usually a squirrel-cage induction) motor is connected to a Lewellen variable-speed transmission with a silent chain drive. The variable-speed shaft of the transmission is connected by chain to a Ganschow speed reducer, the low-speed end of which drives the conveyor. These are used in automobile assembly lines, as already explained, on body building conveyors, continuous drying and japanning ovens, and other similar work.

Factors Which Govern Proper Installation

Information the user must give to assure adequate equipment for the service conditions.

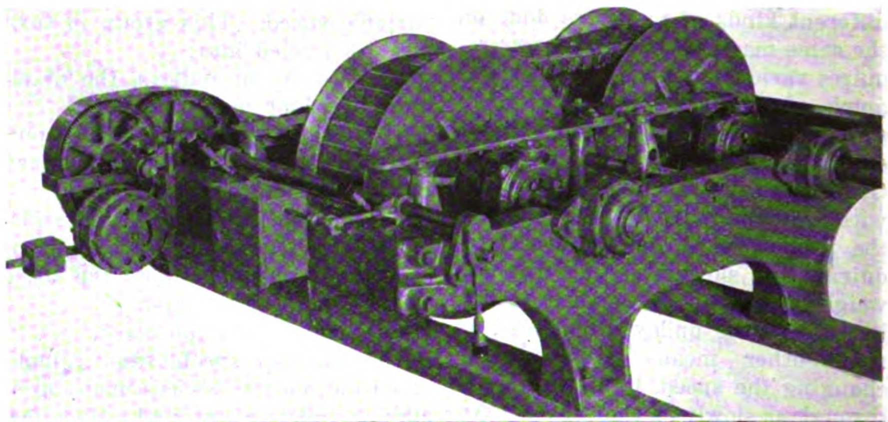
1—Kind of machine to be driven.
2—Diameter of machine driving pulley.
3—Width of belt on this pulley.
4—Fastest speed wanted on this pulley.
5—Slowest speed wanted on this pulley.
6—Speed of shaft from which transmission will be driven.

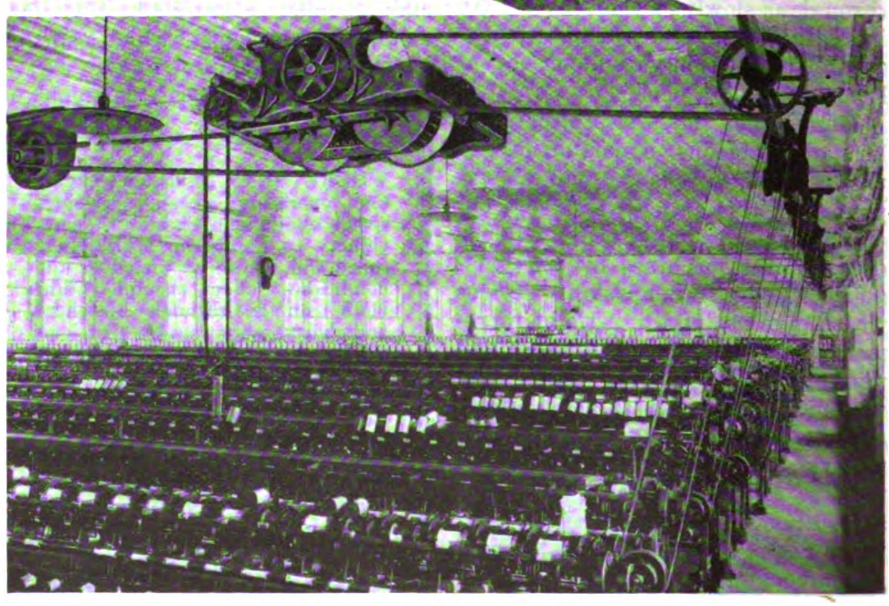
If an individual motor drive give the following additional information:

7—Horsepower rating of the motor.
8—Speed of motor.
9—Is motor to be connected by belt, chain or direct?
10—Diameter of pulley or sprocket on motor.
11—Width of belt on motor pulley or width and pitch of chain.

Where different types or weights of work go through a similar process is another place where variable speed is of advantage. For example, in galvanizing sheets, the continuous conveyor conducts the sheet through the furnace. The speed of travel depends upon the temperature of the furnace and the thickness of the sheets. The variable-speed devices give a close speed variation which can be quickly changed if conditions warrant. Veneer driers use a variable-speed mechanism in much the same way and for the same purpose, except that here the variation is necessary on account of different thicknesses of veneer and different woods used.

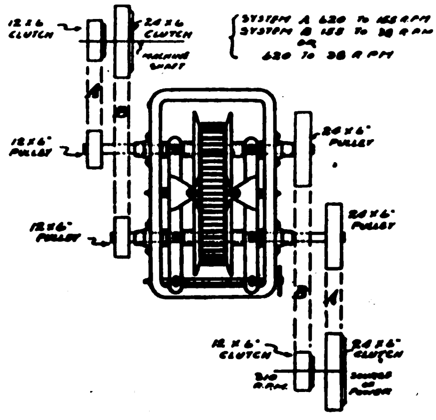
Bread bakeries, cake and biscuit plants make up an industry which offers the second largest opportunity to use these variable-speed devices. Many applications here are listed in the table on page 521. One example





A detail of a variable-speed transmission and also an application in a textile mill.

The illustration at the top shows a complete ball bearing, Lewellen variable-speed transmission with automatically controlled motor, safety stop, demountable screw bearings and other features. In this case the V-shaped belt connecting the two pulleys is set at about a 1 to 1 ratio. As the diameters of the pulleys are changed by moving the cone-shaped disks farther apart or closer together the ratio is changed. The automatic shifting mechanism is shown at the left end. The lower illustration shows an application of a Reeves variable-speed drive in a silk mill.



One method of obtaining high ratios through the use of clutches and more than one pair of pulleys.

This indicates two systems of transmitting power to get high ratios. On line-shaft or other source of power is mounted two clutches and pulleys, 24 in. x. 6 in. and 12 in. x 6 in. While the 24-in. x 6-in. clutch through system *A* is driving, the 12-in. x 6-in. clutch on system *B* is floating and the 24-in. x 6-in. clutch on the machine to be driven is also floating, while the 12-in. x 6-in. clutch is engaged. In other words, while system *A* is engaged entirely, system *B* is floating. Following through system *A* starting at 310 r.p.m. on line shaft, it turns shaft on machine to be driven from 620 to 155 r.p.m. When this limit is reached then system *B* is brought into engagement and immediately thereafter system *A* is released. This then carries the transmission on to further reduction and the speed of 38 r.p.m. is reached on the machine, or, in other words, variation of from 620 to 38 r.p.m. may be obtained through this double system of clutches and pulleys.

shows the advantages obtained. The time of baking different cakes and biscuits (cookies or crackers) varies with the kind and thickness. Obviously, an attachment which will vary the speed of the conveyors in the continuous ovens to fit the varying products would be of advantage, and not only increase output but the quality of the goods. The same is true of icing trolleys and cooling conveyors.

The possibility of greatest use of variable speeds probably lies in the textile industry. How these have been used in "filling" has already been mentioned. In a silk mill, for example, the installation of variable-speed transmissions to the throwing frames resulted in a reduction of 80 per cent in the number of the broken fibers. Now the throwing machines are started up at 1/10 of the operating speed and gradually are thrown into full speed by the variable-speed equipment. Before stopping, the machine is run down to its lowest speed. It is in the starting and stopping process that the most of these fibers are broken. This machine alone eliminated about 75 per cent of these breakages and with the addition of a fly-wheel to give it a more even operation, an additional 5 per cent was gained. The manufacturer estimates that these machines pay for themselves every sixty days and now has twenty-six installed.

Space will not permit of an extended explanation of each application included in the list below. Those familiar with the processes in the industries listed can understand the value of a variable speed instead of a fixed or stepped speed if they but bear in mind the following general characteristics of this equipment in relation to the work or process: (1) Progressive conveyors or machines handling various types, gages, weights, quantities or products. (2) Where it is necessary or desirable to start in slowly and work up to a higher speed, or to reverse the process in stopping. (3) Where the speed of the machine depends upon some other machine or process.

Stoker feeds, governor control of variable-speed engines and machines operating in tandem are common examples of this third application. Operation of machines of this third type has led to the development of automatic and remote control for the variable speeds. For example, stokers are controlled by the boiler pressure. Blowing and other variable-speed engines are also controlled through the governor by the pressure.

Machines in tandem are usually controlled by the process. For example, illustrations *F* and *G*, page 522, show how a rope-reeling frame is controlled by the slack between the rope machine and the reel. The reel speed thus slows up automatically as the diameter of the coil increases. Sometimes tandem machines are controlled mechanically as by the floating roll on the textile machine shown as *E*, page 522, and in the sketch on page 524.

Many automatic and remote controls of variable-speed transmissions are used on textile machines, paper mills, wire and rope machines, biscuit machines and others operated in tandem. Remote control may be provided so that the different machines may be controlled by push buttons in several locations. Indicating and recording tachometers are commonly used in connection with remote control. With hand control where tachometers are not used, an indicating scale may be so placed as to show the speed for any position of the hand wheel. One of the big advantages of remote control lies in the ease with which the speed can be changed. If the worker can vary the

Some of the More Common Industrial Applications of Variable-Speed Transmissions

Bakeries and Biscuit Plants—For driving cutting machines, dough mixers, icing and marshmallow beaters, wafer machines, icing trolleys, cracker cooling conveyors, cracker machines, pan elevators, depositing machines, horizontal and vertical ovens, cone machines, pretzel machines, embossing machines, soft cake machines and other equipment.

Canneries—For driving can fillers, cappers, pea viners, blanchers, exhausters, bottling machines, elevators and conveyors.

Rubber Mills—Coating, wrapping and tubing machines, bias shears, strippers, conveyors.

Laundries—Flat piece ironers, centrifugal wringers.

Machine Shops—For driving planers, boring mills, shapers.

Cement Mills—For driving kilns, coal feeders, conveyors.

Paper Mills—For driving fourdrinier machines, cylinder machines, winders, cutters, engine governors, pumps, calenders, coating machines.

Wire Mills—For driving drawing, galvanizing, coiling, insulating, fence loom, screen japaning, steel cable and armored conduit machines.

Mining—Ore crushers, concentrators, conveyors, sintering frames.

Power Plants — Stokers, pumps, fans.

Veneer Mills—Lathes, dryers.

Textile Mills—For driving tenter frames, dryers, washing machines, moisteners, mangles, starching and printing machines, singers, mercerizers, silk throwers, winders.

Paper Box Factories—Corrugators, double enders, double backers, pasting machines, creasing machines, cutters, slotters, printing presses.

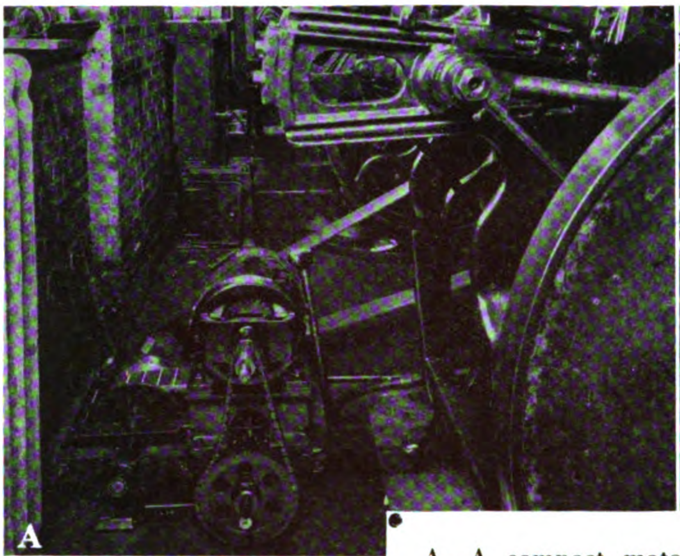
Packing Plants—Hog and cattle rails, viscera and cutting tables, steam tables, conveyors, butterine rolls, dehairing machines.

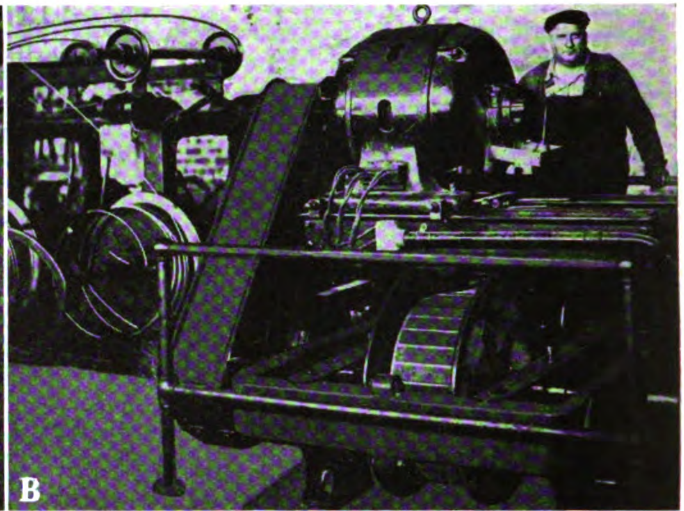
Automobile Factories — Assembly conveyors, tempering furnaces, elevators, enameling ovens.

Miscellaneous Machines—Envelope machines, oil agitators, rotary ovens, wall paper machines, match making machines, clay working machines, sugar granulators, glue cookers, glue spreaders, candy machinery, printing presses, excelsior machinery, paint grinders, paper coating machines, crayon presses, soap presses, crepe paper and roofing paper machines, some chemical processes and any others on which speed regulation is desired.

Applications of Variable-Speed Transmissions

Ten Typical Installations in Different Industries





A—A compact motor drive operating a platen printing press through a variable-speed transmission unit.

B—Variable speed enables each gage of wire to go through the galvanizing process at the proper speed.

C—The drive end of one type of hydraulic variable-speed transmission which will give any speed from zero to the input speed.

D—Automatic control of the feeding speed by changes in boiler pressure may be applied to variable-speed stoker drives.

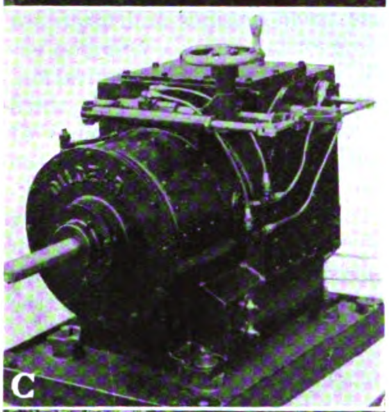
E—An installation of a variable-speed control on a biscuit machine.

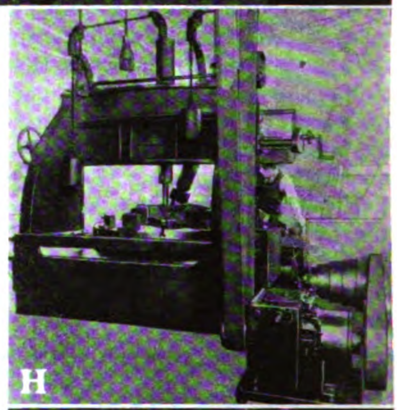
F and G—The slack of the rope between a rope machine and the reel controls the variable-speed unit through the electrical equipment in the box (F) and automatically maintains the reel at the proper winding speed.

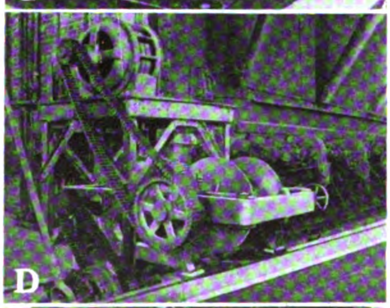
H—Hydraulic variable-transmission application on a boring mill.

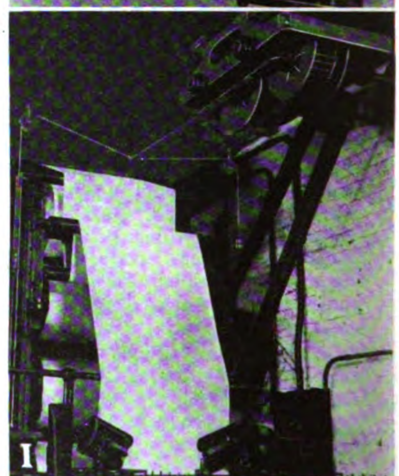
I—This floating roll and counterweight automatically shift the variable-speed lever on this tentering frame in a textile mill.

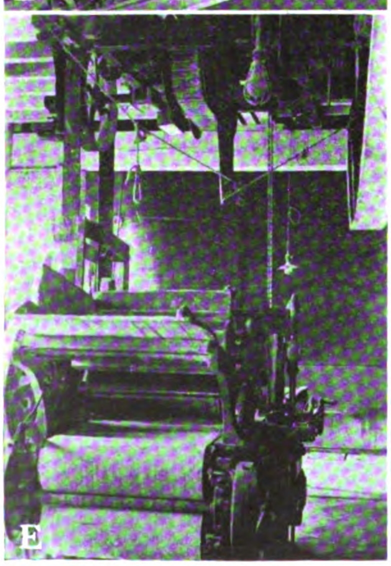
J—A manually-controlled, variable-speed drive regulates the operation of a traveling bread oven.

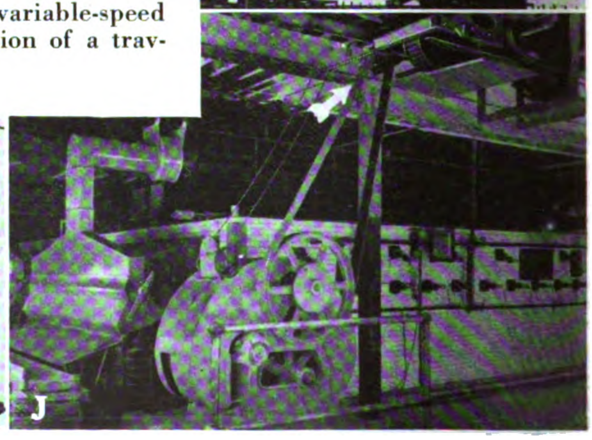


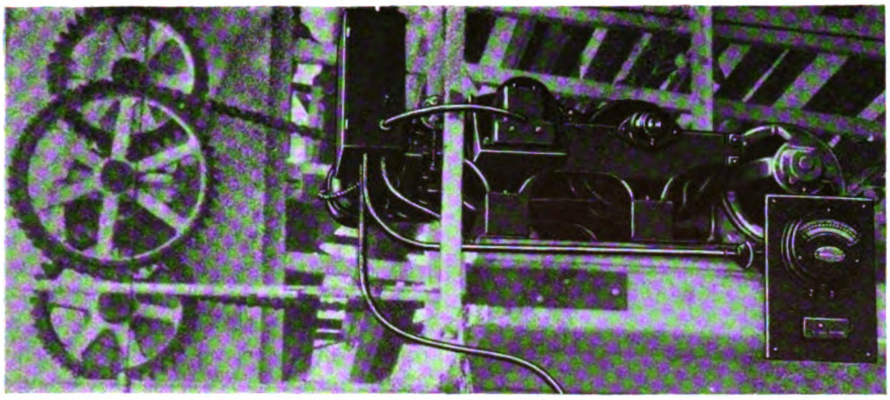












An installation of a variable-speed control in a bakery.

Here a variable-speed transmission operates a bread cooler and proofer. This has push button control and an electric indicating tachometer. In installations where the machines are on different floors control panels are located on each floor together with an indicating tachometer on each panel. In this way, an operator on any floor knows the exact running speed at all times and the arrangement is such that the speed can be controlled from any floor at any time. In some cases indicating tachometers are located on the oven or other machines and recording tachometers placed in the office.

speed from any of a number of positions by pushing a button he is more likely to do so than if he has to walk to the other end of the machine and turn a crank. Where they have been installed it has been found that the operators actually use them.

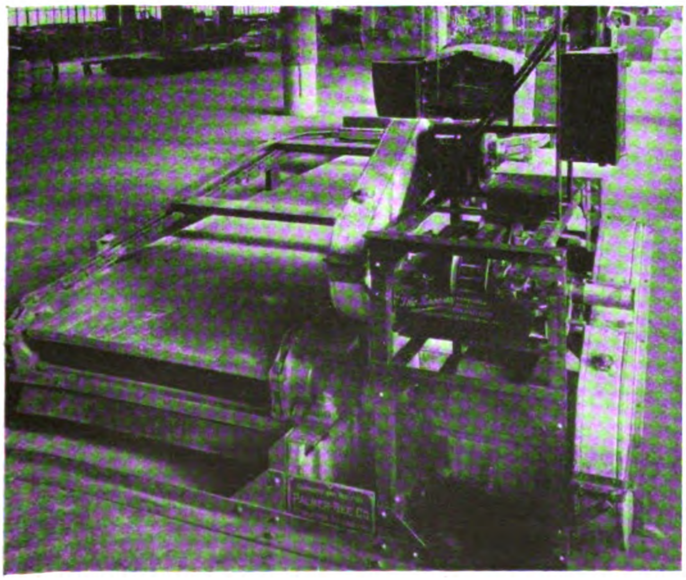
Some of the advantages which are claimed for the mechanical variable-speed transmission are: (1) Minute adjustment over the variable range both above and below the driving speed. (2) High ratios of speed changes; machines of the different capacities can be obtained in a number of classes which give from a ratio of 1 to 1½ up to about 1 to 8 or 10 and in some sizes up to 1 to 16. (3) The horsepower-variation ratio is less than the speed-variation ratio between their maximum and minimum. For example, on a speed variation of 1 to 12, the horsepower variation may be in the ratio of approximately 1 to 4½. (4) The speed is easily changed by hand, automatically or by remote control. (5) The device may be installed on the ceiling, on the floor, or on the wall. (6) It may be connected to the most efficient type of motor, to a lineshaft, or to any other driving mechanism. (7) The mechanism is simple, easily installed and maintained.

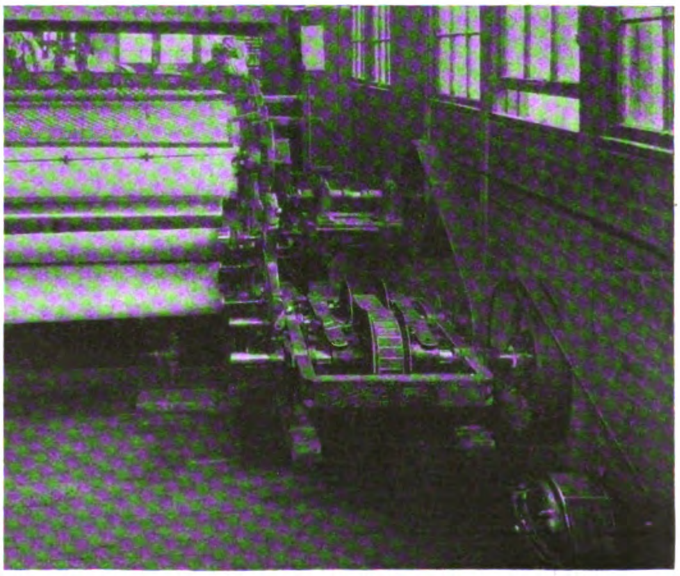
Ordinarily, this type of variable-speed transmission is not used on machine tools as generally these tools are provided with a number of speed changes and means as through the cone pulley or through the gearing which will give sufficient steps to get any desired speed. They could probably be used to advantage, however, on boring mills or on large lathes which are doing a great deal of facing work across pieces of large diameter, as they could be arranged to maintain a constant speed at the cutting edge of the tool irrespective of the change in diameter of the parts faced. These variable-speed devices have been used on metal planers by attaching the quick-return drive belt to the constant-speed shaft of the variable drive, and the cutting or driving belt to the variable-speed shaft. This enables a quick return to be obtained without using a pulley of large diameter and also gives a varying speed for the cutting tool.

It is well to consult with the manufacturer in determining upon a variable-speed transmission. He can base his advice on the information obtained in response to the questions in the box on page 520. Although this is a sturdy piece of equipment, and practically everlasting in the ball-bearing type, there are still some points which require consideration, as does all mechanism. Ball bearings need oiling only once or twice a year, depending upon the service conditions. Transmissions with self-oiling bearings require more frequent attention. Dust or abrasives do not have any appreciable effect upon the drive as they are jolted or fall off the cone-shaped pulley. However, if oil or grease are left on the cones, the dust sticks and becomes somewhat more abrasive. Careful oiling will prevent this. Also, oil on the

Applications of a variable-speed transmission unit in an automobile body plant and in a laundry.

In the automobile body plant at the left a Reeves variable-speed transmission is connected into a Palmer-Bee conveyor system. This is used to give a variation in the control of the speed for different production output. The illustration at the right shows an application on a flat-piece ironer in an Indianapolis laundry. It enables a laundry worker to get the most out of the ironer by allowing her to select quickly the speed best adapted to the classes of work which go through. Some work obviously requires slower, more careful handling and, if thicker, more heat, while other work can go through much more rapidly.

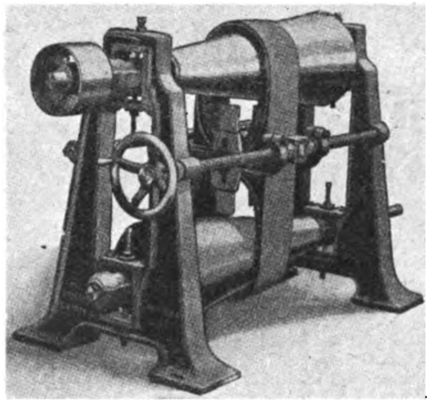




rubber belt holding the V-blocks rapidly deteriorates it. This also may be prevented with care. Do not try to change the speed adjustments by shifting the disks while the drive is standing still.

Where it is necessary that variable-speed transmissions operate in hot locations, the V-block may be attached to a steel or chain belt which is not affected by the heat or other conditions. In some industries, such as in canning plants, where the drives are used only for a short time during the season, the manufacturers recommend that the main shafts and other bright parts receive a good coating of grease when the machinery is shut down for the idle period so that it may be put into shape quickly and easily at the beginning of the next season.

On transmissions in which a pair of cone pulleys are connected by a belt, as is illustrated at the top of the page, special belts are used. Here special short, endless belts made up of wedge-shaped leather blocks fastened to the inside of another belt are placed around each pulley. The driving belt, which goes around on the outside of the two short belts, rests on parallel surfaces and is not twisted as it would be if it rested directly upon the two cones. Another type of two-cone, variable-speed transmission has the pulleys close together and a short endless belt around one of them. The power is transmitted through the pressure applied to the belt which is moved along the length of the two conical pulleys and gives the varying speed. Some types of two-cone, variable-speed drives are connected by belts which may be shifted. Because the two faces are not parallel this type works better with the belt crossed. One type which is sometimes used consists of a narrow belt next to the two pulleys which has riveted to it, on the outside, another, somewhat wider belt to receive the wear of the shifting device. These are frequently used in place of countershaft drive in machinery and in the larger sizes in some of the same types of work on which mechanical variable-speed devices are used.



A special type of taper cone variable-speed drive.

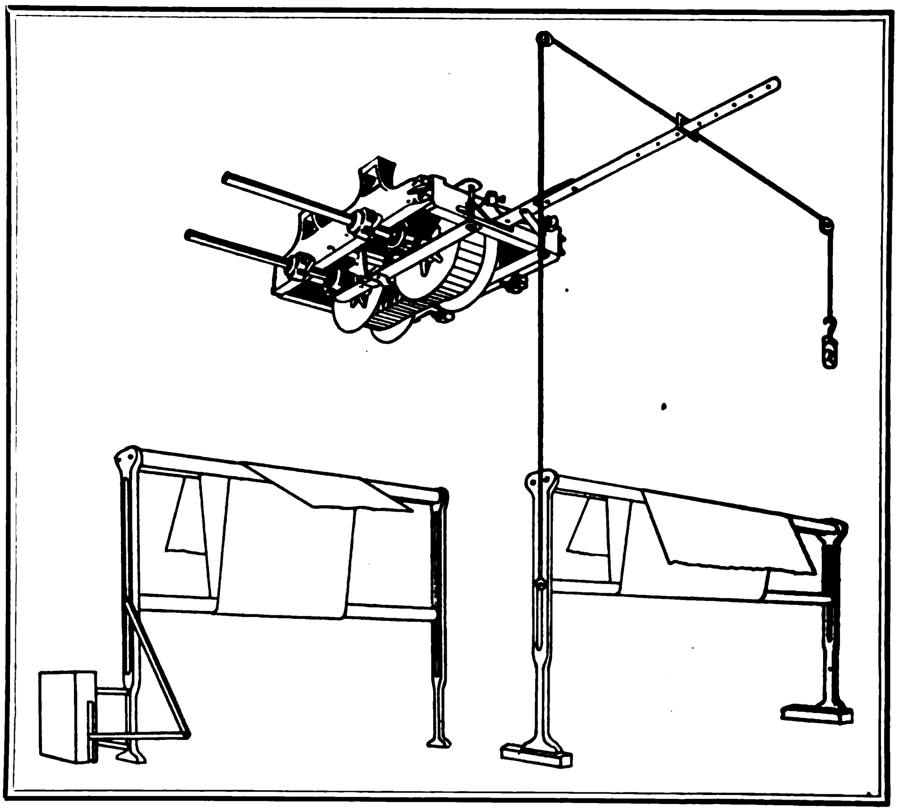
One of the principal difficulties in applying a belt to a drive of this sort is due to the taper of the cones. The feature of this speed changer is in the method by which a level bearing surface is provided for the belt. This is obtained here by means of patented cone pulley transformers which consist of a series of tapered leather strips riveted to short, endless belts, one of which is placed around each cone. These provide parallel pulley surfaces, for the driving belt. The speed changes are made by shifting the belt by the mechanism shown.

One Type of Hydraulic Variable Speed Transmission

One type of variable-speed hydraulic power transmission is shown in illustrations *C* and *H* on page 522. In another case it was connected to a lathe used in turning elevator sheaves in place of the cone pulley to give a wide range of speeds quickly. Here the transmission is driven by a 7½-hp., 1,800-r.p.m., squirrel-cage motor.

This hydraulic transmission consists essentially of a variable-displacement pump, pumping oil to a constant-displacement motor. When the stroke of the pump is set at a maximum, it delivers a fixed quantity of oil to the motor and forces the latter to rotate at a speed equal to that of the pump. As the stroke of the pump is reduced, the amount of oil pumped is decreased and the motor will rotate more slowly. Any speed of the driven shaft may be obtained from zero up to the speed of the original driving shaft by merely changing the stroke of the pump. This can be done by ropes on pulleys or by an extended hand wheel which is placed within reach of the machine operator. This device is claimed to deliver an even torque throughout the reduction. It is put out in two sizes, one rated at from 10 to 15 hp., and the other from 5 to 7½ hp. capacity. It is designed primarily for use in driving lathes, boring mills, cranes, paper mill machinery and other equipment where variable speed or instant control is desirable.

The fourth type of variable-speed devices, those with friction units, are used with more or less success in some kinds of work. For example, some types of light friction drill presses use (*Continued on page 555*)



Examples of mechanical and automatic control of variable-speed transmission units.

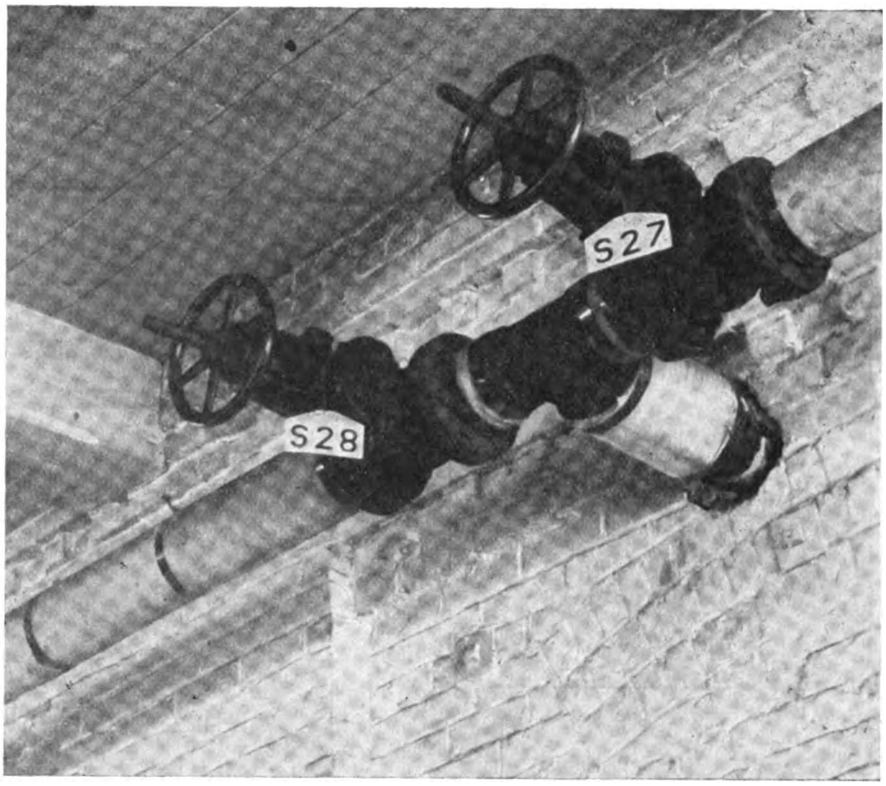
In the illustration at the right, the operating or shifting lever is controlled by the floating roll through a cable or a chain. The shifting screw is omitted and the speed is controlled by the lever and determined by the position of the floating roll. The small illustration at the left shows the method of controlling the speed electrically through a floating roll. The electrical control is also used where the variable-speed transmission is too far from the roll to be operated mechanically.

Here Are Some Easy Ways of

Identifying Pipe Lines And Valves

In Industrial Plants Together With Records That Simplify Tracing, Installation, Maintenance and Repair of This Equipment

By DAVID FLIEGELMAN
Chain Design Division, American Chain Co., Bridgeport, Conn.



This shows how easily the black letters on the white background of the valve tags may be read from a distance.

PRACTICALLY all industrial men have had experience in tracing out pipe lines or hunting for valves which cut off a section so that changes or additions may be made or other work done on the line. If the lines or valves are without means of identification there is always danger of making an error with possible disastrous results. While many factories have a partial scheme of identifying pipe lines it would be worth while carrying it on throughout the plant. One complete color scheme which has worked out satisfactorily in several instances is given in an accompanying table. Where a system is already partially identified according to another scheme this may be modified to suit the work already installed.

The fire lines include the sprinkler system, indicator post valves and firehose connections. Live steam piping is usually covered to prevent loss of heat by radiation and as these coverings are usually white they fall in with the above color scheme. The paint used should be especially adapted for the purpose.

Copies of the adopted code should be furnished to all those interested in order to get them acquainted with the colors and their significance. It is naturally understood that only the exposed piping is painted. Not only do the painted pipe lines make a neater appearance, but they assist in following up a certain line when necessary, or in identifying a certain line when a new connection or branch is to be added.

Supplementing the scheme of painting the pipe lines according to some adopted code, all valves should be tagged. In one plant, valves above ground carry a 15-gage sheet metal plate of the dimensions shown in the sketch; the letters are 1¾-in. high and the plates are painted white all over. The numbers are painted in black, which allows them to be seen across the room. The illustration at the heading of this article is of a photograph of two valves suitably tagged. The tags are wired to the valves in such a manner that the numbers can be readily seen by one looking for them. Care must be taken, however, to see that the tags are placed so that they do not interfere with operating the valve.

Valves located in pits or tunnels carry small brass tags ¾-in x 2-in., similar to those used in tagging machines, upon which the valve numbers are stamped.

One Method of Identifying Pipe Lines

Fire Lines	Red
Hot Water	Light Green
Cold Water	Dark Green
Drains	Blue
Live Steam	White
Steam Returns	Brown
Heating Lines	Black
Gas	Yellow
Oil	Drab

The method employed in numbering the valves makes use of a letter in conjunction with a number to help identify it. All valves on fire lines are lettered *F*; on hot water lines *H*; on cold water lines *W*; on live steam lines *S*; on steam return lines *R*; on gas lines *G*; and on oil lines *O*. In this way the code letter assists in identifying any pipe line by indicating its purpose. This system of identifying the valves can be used even though the pipe lines are not painted according to any prescribed code. For that matter, a simple system of identifying the valves is even more necessary and valuable when the pipe lines are not coded.

The valves are numbered in order, as far as possible. For example, the main valve controlling the cold-water supply to all the factory buildings, is tagged *W-1;* then come the valves controlling the water supply to each building, as *W-2*, *W-3*, and *W-4*. The cold-water valves in each building are then tagged in rotation. The same method of numbering can be applied to the other valves on the gas, steam, hot water and other lines.

After the valves are tagged, valve service sheets are gotten up in blueprint or printed form, so that sufficient copies can be made for distribution. These sheets tell at a glance

29

W-16 - 1¼" Valve, located in basement Bldg. "A", in front of toilets. Together with W-24 controls cold water supply to all toilets and washstands in Bldg. "A".

W-17 - 1" Valve, located in Bsmt. Bldg. "A" (about 20 ft.east of toilets). Controls cold water supply to Welding Machines in Dept. 7 (2nd floor, Bldg. "A".)

W-18 - 2" Valve, located in Bsmt. Bldg. "A" (opposite Bldg. "G"). Controls cold water supply to Bldg."G" and part of cold water supply to Bldg. "L".

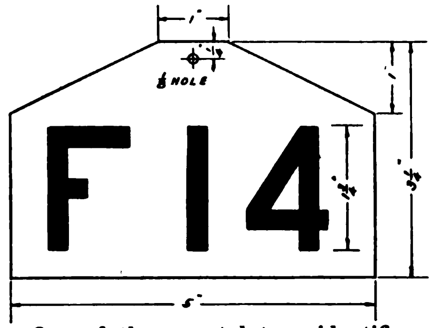
W-19 - 2" Valve, located in Bsmt. Bldg. "C", in front of toilets. Controls cold water supply to washbasins in Bldg. "C".

W-20 - 1" Valve, located in Bsmt. Bldg. "C", in front of toilets. Controls cold water supply to factory office washrooms on 2nd floor Bldg. "C" and also to drinking fountains near Elev. #8 on all floors in Bldg. "C".

One page of the loose-leaf valve record.
This valve record contains complete information about each valve such as: its number, location, size, function and, if a special valve, when to be opened or closed and by whom. The key valve controlling each department is found by consulting the valve service chart shown in an accompanying illustration.

the various valves that control the cold water, hot water, steam, and other lines on each floor or in each department. A sample sheet is shown in one of the accompanying illustrations.

The service sheets are supplemented by 3½ by 6-in. loose-leaf notebooks. These books contain complete information covering all valves,



One of these metal tags identifies each valve.

such as: (1) valve number, (2) location, (3) size, (4) function and, if a special service valve, (5) when to be opened or closed, and (6) by whom. Complete copies of these notebooks are furnished to the works manager, factory superintendent, factory engineer, boss piper, and night watchman. The copies supplied to the foremen include only the valves which are of interest to them, so that should there be a leak or break in any of the lines on their floor or in their department, the foreman or the assistant foreman will know what valve to close and exactly where it is located.

If a sprinkler head accidentally opens, it is advisable to shut off the water supply as soon as possible to minimize the damage done by the water. To facilitate this and to acquaint everyone with the location of the post indicator valve controlling the sprinkler system on each floor or in each department, one or more "sprinkler" cards should be posted conspicuously in every room. A sample card is shown herewith. I be-

Sprinklers

In case a Sprinkler Head in this room breaks, shut off Indicator Post Valve.

No. F 11

Located in yard on east side of this building.

Also open drain pipe valve

No. F 110

Located in basement of this building.

Much water damage may be prevented if notices like this are placed conspicuously.

lieve this card is more effective when lettered in red. These cards can be framed or given a coating of white shellac which protects the surface from soiling and keeps the printing from fading.

Some valves are to be opened only by certain people in authority. These valves are usually in the sprinkler system and in the live-steam lines in the boiler room. Such valves are usually kept open, but when necessary to close one of them in case of repair, a red paper tag is attached to the valve, giving the following data: (1) when closed, (2) why closed, (3) by whom, and (4) for how long. A duplicate red tag is filled out and is sent immediately to the superintendent's office.

When repairs are made and the valve in question is opened, its tag is removed. A green tag, giving the additional information relative to the re-opening of the valve, is sent to the superintendent who files it away with the red tag previously sent him. These green and red tags are usually furnished by the insurance companies.

VALVE SERVICE

BUILDING	FLOOR	DEPT. NO.	SPRINKLERS	COLD WATER	HOT WATER	H.P. STEAM	H.P. RETURNS	L.P. STEAM	L.P. RETURNS	TOILETS	FOUNTAINS	WASHBOWLS	GAS
A	BSMT.	5	F-6		H-7			S-25	R-2	W-16	W-24	W-16	
A	1ST.	8	F-6		H-7			S-25	R-2	W-16	W-24	W-16	
A	2ND.	7	F-6		H-7			S-25	R-2	W-16	W-24	W-16	
A	3RD	17	F-6		H-7			S-25	R-2	W-16	W-24	W-16	
A	3RD.	14	F-6		H-7			S-25	R-2	W-16	W-24	W-16	G-6
B	BSMT.	5	F-3		H-7			S-23	R-3			W-12	
B	BSMT.	16	F-3					S-23	R-3				G-4
B	1ST	1	F-3					S-24	R-4	W-12	W-13		
B	1ST.	2	F-3					S-24	R-4	W-12	W-13		G-4
B	1ST	3	F-3					S-24	R-4	W-12	W-13	W-12	
C	BSMT.	5	F-11		H-5			S-27	R-2	W-21	W-20	W-19	
C	BSMT.	15	F-11		H-5			S-27	R-2	W-21	W-20	W-19	
C	1ST.	8	F-11		H-5			S-28	R-3	W-21	W-20	W-19	
C	1ST	7	F-11		H-5			S-28	R-3	W-21	W-20	W-19	
C	1ST.	9	F-11		H-5			S-28	R-3	W-21	W-20	W-19	
D	1ST.	12	F-10	W-31	H-4	S-10				W-28			
K	1ST.	22	F-14	W-33	H-3	S-32			R-3	W-34	W-47	W-34	G-2
L	1ST.	21	F-7	W-41		S-36	R-8	S-16	R-5				G-5

Valve service sheets such as this are made out for every valve.
This chart shows the valves which control the water, gas, steam and other feed lines in each of the various buildings and departments. In other words they are the key valves. A glance at this chart shows the valve wanted. The exact location of that valve is given in a loose-leaf notebook a sample page of which is shown in one of the accompanying illustrations.

SHOULD THE SMALL hoist be hand operated or motor driven? If it is to be motor driven, should a series-wound, direct-current, or a squirrel-cage, alternating-current motor be used? Should a manual controller be selected, or is a magnetic controller justified? How many and what kind of brakes should be specified? What overtravel limits should be provided? What features should the different parts of the hoist have to insure low maintenance and satisfactory operation? In this article Mr. Hunter answers these questions and many more concerning the operation of small hoists.

Things It Pays to Know About the

Operation and Selection of Small Hoists

Together With the Types and Operating Features of the Control, Brakes and Overtravel Protection

By R. B. HUNTER
Electrical Engineer, The Cutler-Hammer Manufacturing Co., Milwaukee, Wis.

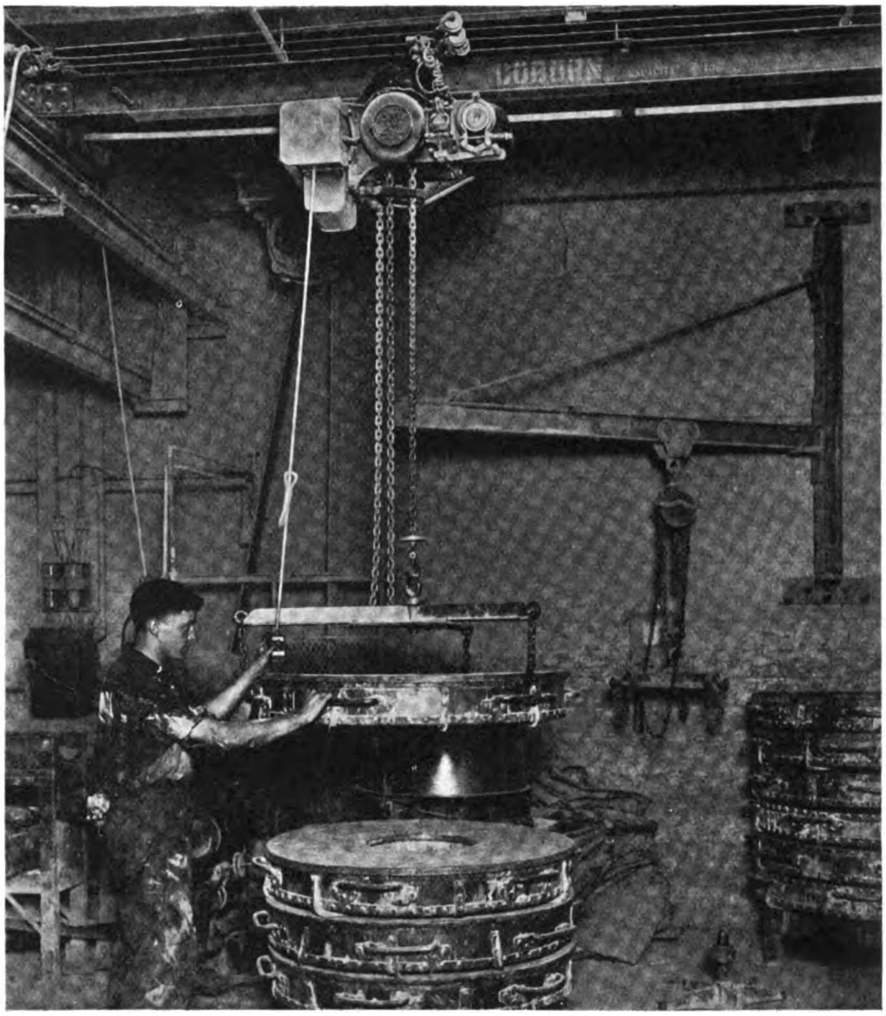
THE MODERN successor to the chain block, is the electric hoist in ½-ton to 2-ton capacities. While the factors which justify the larger investment may be quite varied, there is always one underlying reason for the choice of the electric hoist. This is the human factor; man power is multiplied by its use and men can be selected on a basis other than brawn. For this reason, in selecting a hoist, careful consideration should be given to all the parts that make up the hoist, and in particular to the control, which is the link between the operator and the hoist, and between the hoist and the source of power.

The elements of the electric hoist are: (1) the suspension; (2) the motor; (3) the gear reduction between the motor and (4) the winding drum, on which is wound (5) the chain or cable terminating in the hook or other load-supporting device; (6) the control; (7) a brake to retard the load during lowering and to hold it suspended; (8) a brake to stop the motor; and (9) a stop to prevent overtravel of the hook and block.

When the power supply is direct current, the series-wound motor is universally used for small hoists. When alternating current is available, the squirrel-cage motor is almost always used; the slip-ring motor is used only when accurate control of speed is required. Slip-ring motors are more expensive, require more maintenance, and necessitate the use of a more expensive control; for these reasons their use is avoided, whenever possible.

For controlling the starting, stopping and speed of the motor, there are two general types of control: namely, manual control and magnetic control.

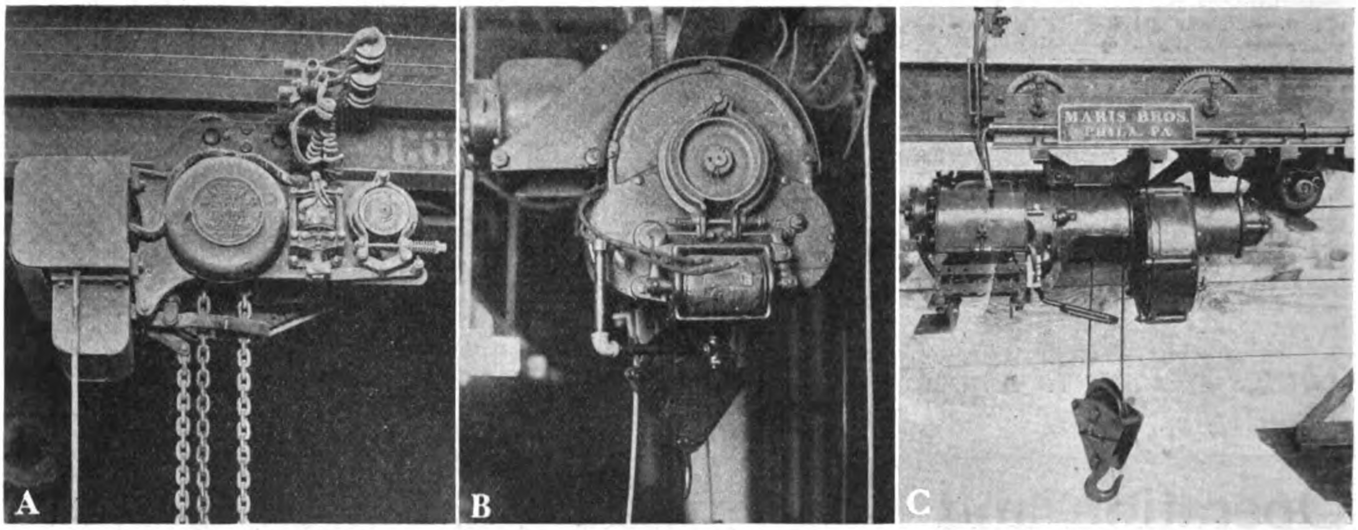
A hoist with manual control is shown in illustration G on page 529 and in illustration C on page 554. The manual control is operated by pulling the proper cord for hoisting or lowering, the magnetic control by pushing the proper button. Sometimes the push buttons are located at the end of a conduit which forms a convenient means for pushing the hoist along its track, as is shown in the illustration at the bottom of page 528. More frequently, the push buttons are mounted in a pendant station suspended from armored cable. It is essential that firm and reliable anchorage be provided between the armor of the cable and the pendant station, for if this ground is broken there is always danger of shock to the operator. For the same reason, the armor should be firmly anchored to the metal frame of the hoist.



This small hoist has a magnetic controller which is operated from the push-button switch in the operator's hand. A close-up view, showing the details of the hoist is given at A on page 528.

ADVANTAGES OF MAGNETIC CONTROL FOR SMALL HOISTS

The principal advantages of the magnetic control over the manual control are: (1) ease of operation, (2) accuracy of "spotting" the load, and (3) reduced maintenance. When the manual control is used, the proper contacts are closed by pulling the cord, and a spring opens the contacts when the cord is released. A considerable motion of the cord is required, and the parts have some inertia; so there is a small time inter-



val between the pull or the release of the cord and the corresponding action of the hoist. While a skilled operator can make some allowance for this, no such allowance is required when the magnetic control is used, the action of the hoist being practically instantaneous upon depressing or releasing the push button. With magnetic control, it is easily possible to "spot" the load, hoisting or lowering, at full speed, within half an inch of the desired point.

If starting and stopping of the hoist are very frequent, magnetic control should be selected regardless of other conditions, because of reduced maintenance expense. A one-minute cycle may be considered as being severe enough to justify the added expense of magnetic control, even though manual control is otherwise satisfactory.

The prospective purchaser of an electric hoist should also consider whether delays for repairs will involve large expense due to loss of production. While a well-designed control of either the manual or magnetic type will probably be the cause of fewer delays than are caused by failure of other parts of the hoist, the magnetic control will in general require less frequent adjustment than the manual control, and may for this reason, even in light service, be desirable, if it is a part of a high-production unit.

Manual Control Is Required by Some Applications

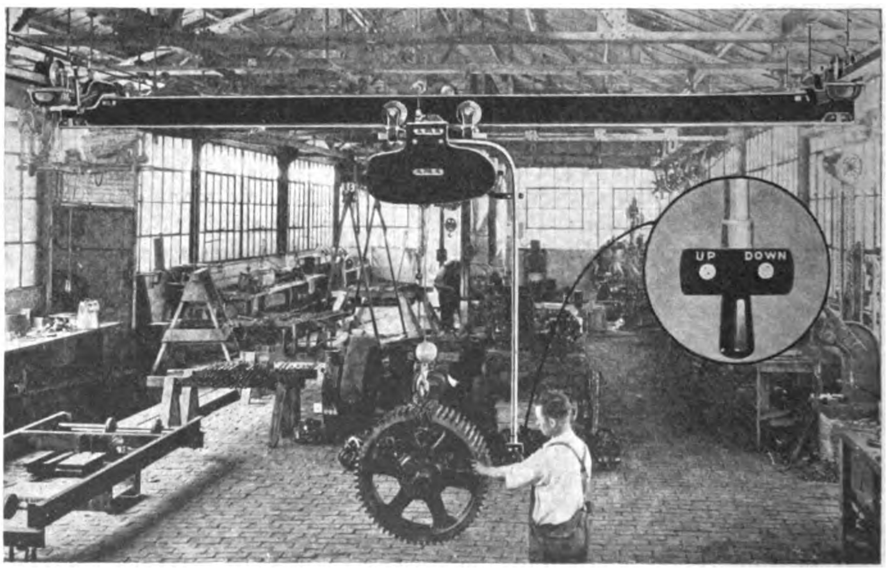
It must not be concluded, however, that the manual control is generally an inferior type. A well-designed, manual controller is a simple and reliable mechanism, and large numbers of them are giving highly satisfactory service. The magnetic type of control requires, in general, a higher

These small hoists are provided with brakes and limit stops.

In illustration *A* is shown a close-up view of the hoist illustrated on page 527. The solenoid-operated brake at the extreme right functions on the armature shaft. The hoisting chain passes through a hole in the operating lever of the limit stop. In illustration *B* is shown a small hoist having a motor-operated trolley. Manual control is used for both hoist and trolley. The hoist has a solenoid brake somewhat similar to the one shown in illustration *A*. At *C* is shown another manually-controlled hoist. The operating lever of the limit switch projects directly above the sheave of the hook block.

grade of maintenance, and where a plant electrician is not available, the simpler manual controller may be preferred. There are also, as will be noted later, certain control features which cannot readily be secured in magnetic control.

For example, in addition to accuracy of "spotting" referred to above,



The push button operating the magnet control for this small hoist is mounted on a rigid arm.

This construction is of advantage as the arm forms a convenient handle for pushing or pulling the trolley along its track or runway.

accurate control of hoisting or lowering speed is sometimes required. In foundry work in particular, this is an essential feature. If, for instance, the full-load speed of the hook is 30 ft. per min., for foundry service, it will probably be necessary to provide for an empty-hook speed of 10 ft. per min. This should be obtainable both in hoisting and lowering, in order to pick up and deposit flasks gently. It is usual to provide three or four speeds when speed control is required, so that the operator can select the speed most suitable to the load and conditions of operation. In general, manual control is preferable to magnetic control for this service, because of the cost, size, and complication of magnetic control with the multi-speed feature. Multi-speed hoists are rarely furnished where alternating-current power is used.

Manual controllers are of two general types—drum type and faceplate type; the faceplate type was the earlier design, but the drum type is now used almost universally. A typ-

ical drum-type controller is shown in *E* of the illustration on this page. It consists of a cylinder carrying copper segments which, when the cord is pulled, make contact with fingers to complete the circuit between power supply and motor.

Factors Governing Selection of Small-Hoist Control

The points to be noted in selecting a drum-type, hoist controller are: (1) Clearance between live parts and ground and between parts of opposite polarity should be ample. Operation of the drum will deposit copper dust on exposed surfaces, and unless the clearances are ample the intervals between cleaning will be unduly short. (2) Barriers should be provided to prevent flashing. (3) Fingers should be readily adjustable and self-aligning with the segments. Finger pressure springs should not carry current. (4) The return spring should return drum cylinder, handle, and cords to neutral position quickly upon release of cord. (5) The centering device should stop the drum positively in neutral when drum is released from running position. (6) The handle should be sufficiently long to operate without excessive pull on the cord. (7) Wearing parts (segments and fingers) should be easily accessible for repair. (8) Drum should be easy to wire. (9) The controller should be enclosed by a dust-proof cover.

The magnetic controller for small hoists consists of two contactors, one for each direction, mechanically interlocked so that both cannot be closed simultaneously, and a two-button control station. Details of a magnetic controller can be seen in illustration *F* on this page. The points to be noted in selecting a magnetic hoist control are: (1) Magnetic blow-out should be furnished on contactors for direct-current service. (2) Ample clearances should be allowed. (3) Contact surfaces should be self-aligning. (4) Coils should be filled with moisture-proof impregnating compound after winding. (5) Controller should be easy to wire. (6) Controller should be enclosed by a dust-proof cover. (7) Push-button contacts and operating buttons should be "husky." (8) A guard should be provided around the buttons to prevent breakage. (9) The case containing the push buttons should be tapped for conduit about 1½ in. in diameter, or should be supported from armored cable.

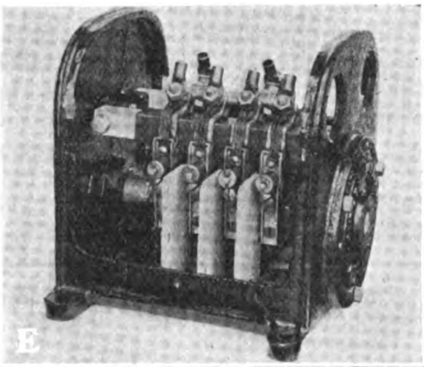
Operation of Brakes Used on Small Hoists

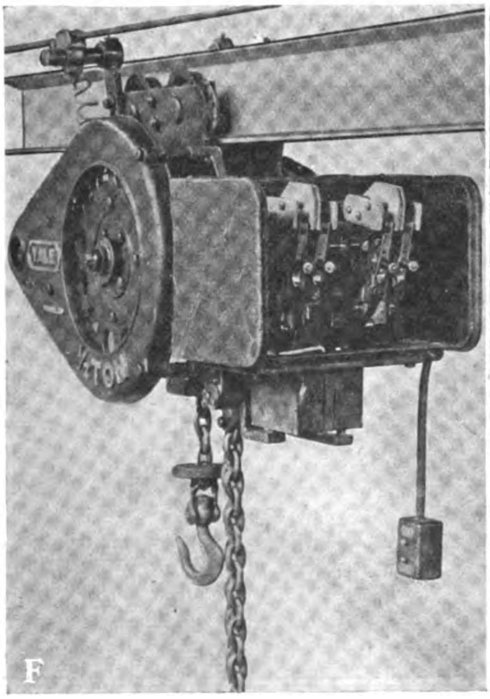
The majority of electric hoists have a friction brake, commonly called the load brake, to control the lowering speed. When worm reduction is used between the motor and winding drum, the worm is made non-overhauling and will hold the load unless power is applied to the motor. When a load is being lowered, the thrust of the worm against a friction bearing is balanced by the thrust due to rotation of the worm by the motor. The lowering speed is thus determined by the speed-torque characteristics of the motor, and will vary inversely with the weight on the hook. If spur-gear or chain reduction is used between motor and winding drum, the lowering speed is governed by friction discs which engage when the load is being lowered and are separated when hoisting, as shown at *(1)* in illustration *B* on page 554.

Instead of a mechanical brake to limit the lowering speed, an electrical (dynamic) brake is sometimes used where direct current is the source of power. The control is so arranged that, when it is moved to the lowering position, the motor is converted into a generator which feeds current

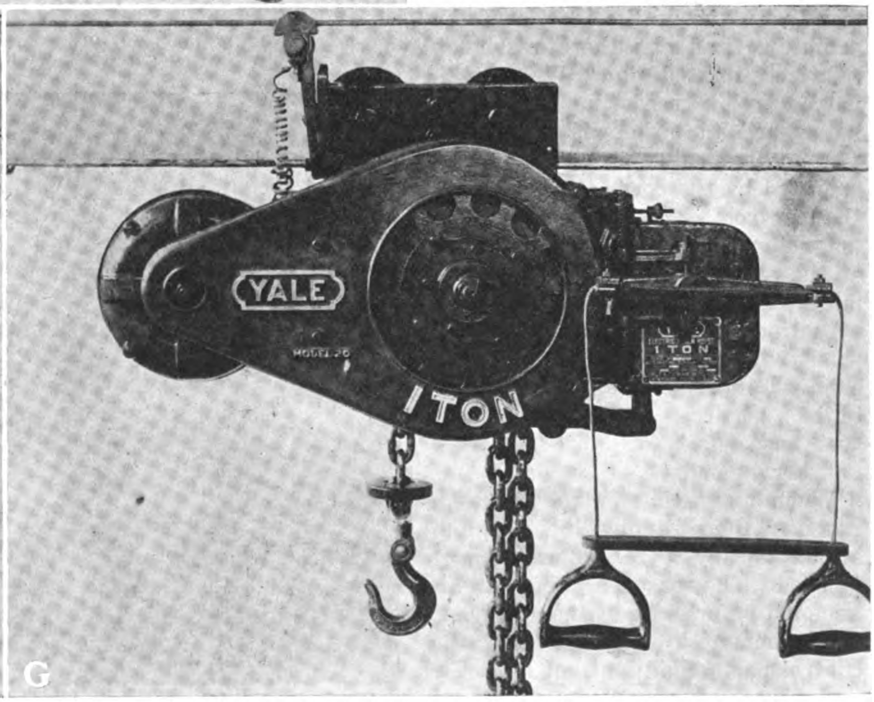
Three views showing manual and magnetic controls as used on small hoists.

In illustration *F* is shown a hoist having magnetic control. As can be seen, the control consists of two double-pole contactors which are controlled from the push-button switch. At *G* is illustrated a manually-controlled hoist. Illustration *E* shows the details of the manual controller. This type of manual control is known as a drum reverse switch. Four fingers or contacts engage with segments on the drum which is operated by means of the two ropes shown in illustration *G*.


E



F



G

Control Accessories Used on Small Hoists

Control		Lowering Brake	Motor Brake	Limit Stop
Manual		Mechanical (a.c. or d.c.)	Mechanical	Mechanical (positive or clutch type)
		Electrical (dynamic-d. c. only)	Electrical	Electrical (main circuit)
Magnetic		Mechanical		
		Electrical	Electrical	Electrical (main circuit or pilot circuit)

into a properly-designed resistor. Briefly, the energy of the falling load on the hook is converted into heat in the resistor, and the speed of lowering thereby governed. The characteristics of the dynamic brake are such that the speed of lowering varies directly with the weight on the hook; that is, a heavy load is lowered a little faster than a light load. Several control points can be furnished, so that the operator can adjust the lowering speed to suit conditions. For hoists of the type discussed in this article, speed adjustment is very rarely necessary. Dynamic braking cannot be obtained with alternating-current motors.

Since the motor drives the load during lowering, a brake is usually applied to the motor shaft when power is cut off to absorb the inertia of the armature, which otherwise would continue to rotate fpr a short time and allow the hook to drift. The brake usually is of the shoe type, applied by a spring. It is not required to stop the load, but merely to take up the inertia of the armature, and can therefore be of relatively light design. When manual control is used, the brake may be opened in either of two ways: (1) mechanically, by some device operated by the cords which actuate the control; (2) electrically, by a magnet whose winding is energized at the same time that power is applied to the motor. The method of operation and the results are the same with either electrical or mechanical operation of the motor brake. Choice is made according to cost and details of hoist structure and arrangement.

When magnetic control is used, however, there is no such choice, and an electrically-operated brake must be used. The reason for this is that, as noted before, one of the essentials of the magnetic control is that the control parts shall be light and easy to manipulate. This means that the release of the brake, which requires considerable effort, must be affected electrically rather than manually. A solenoid-operated brake is shown in *B* of the illustration on page 528.

Small Hoists Use Several Types of Limit Stops

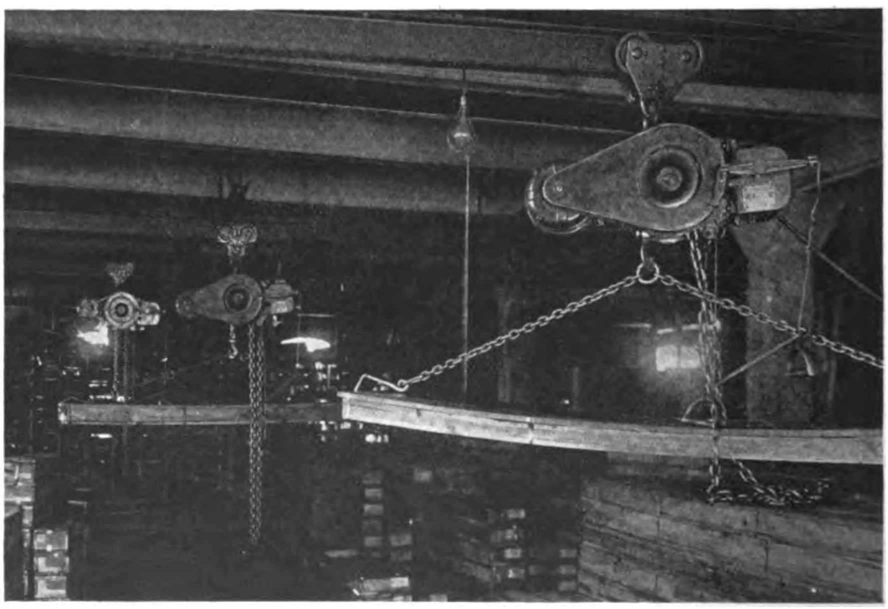
Most electric hoists have a device to prevent overtravel of the hook in the up direction, and sometimes means to limit the travel in the down direction.. When manual control is used, the limit stop may be either mechanical or electrical. The mechanical-type limit stop, which is more frequently used, usually takes the form of a bar which pushes the controller to the neutral position when the hook reaches the danger zone, simultaneously setting the motor brake. Illustration *G* on page 529 shows a hoist control with a mechanical-type limit stop. In another type of mechanical limit stop the controller is of the drum type and is designed with clutch between the contact-making drum and the operating handle. When the hook reaches the danger zone, the clutch is released and the return spring snaps the control drum to the open-circuit position. The clutch is re-engaged by pulling on the reverse control cord. The advantage of this type of overtravel limit is that the contacts are opened and closed very quickly, thus reducing the burning of the contacts and allowing close adjustment of the stop.

The electrical type of limit stop may also be used with manual control. This type of stop consists of a switch in series with the motor, the switch being opened when the hook reaches the limit. The switch must open one line of a direct-current circuit, and two lines of an alternating-current circuit. The lines which are opened in the electrical-type limit stop must be bypassed when the controller makes the circuit for the opposite direction.

The choice of mechanical-type or electrical-type limit stop, like the choice of manually- or electrically-operated motor brake, depends on the relative cost as affected by the details and arrangement of the parts of the hoist.

When magnetic control is used, the electrical type of limit switch is required. This switch may open the motor circuit, in which case the requirements are the same as for the electrical type of stop when used with manual control; or the limit switch may (*Continued on page 554*)

These hoists use an extension cord instead of trolley wires for their power supply.
The extension cord is plugged into the power supply wherever it is desired to hoist or lower the load. This does away with the use of two pulley wires.



Some Symptoms of Lightning Arrester Troubles—

Their Diagnosis and Remedies

Compiled by H. E. STAFFORD,
Electrical Engineer,
Provincial Paper Mills,
Port Arthur, Ont., Can.

SYMPTOM	TROUBLE	CAUSE	REMEDY
1. Gaps continue to arc when set in operating position.	Abnormal arcing.	1. Too small gap setting. 2. Gap electrodes out of shape. 3. Voltage greater than normal due to crossing with higher voltage lines. 4. Generator voltage too high. 5. Films not properly formed.	1. Increase gap setting. 2. Straighten horns to proper alignment. 3. Repair lines if crossed. 4. Adjust generator voltage. 5. Examine cells and renew defective ones.
2. Arc at horns or sphere gaps too intense.	Excessive charging current.	1. Improper charging. 2. Arcing ground on line at time of charging. 3. Electrolyte deteriorated.	1. Use proper method of charging in regard to time, holding the gaps on short-circuit not longer than 5 to 10 seconds. 2. Locate and repair causes of ground or abnormal arcing. 3. Renew electrolyte in cells.
3. A rumbling noise issues from tanks.	Arcing in oil.	1. One or more empty cells. 2. One or more punctured cones. 3. Electrolyte in contact with wooden rods or insulating separators.	1. Fill cells with electrolyte. 2. Remove and replace with new cones, putting new ones at top of the stack. 3. Wash all traces of electrolyte from rods and spacers and see that same does not come in contact when refilling and assembling.
4. Oil is thrown from tanks.	Arcing in oil.	Same as above 3 causes. 4. Electrolyte becomes heated due to prolonged short-circuit of horns or sphere gaps.	Same as above 3 remedies. 4. When this happens, the electrolyte becomes boiled down and it is usually necessary to take down the entire stack, clean each cone, renew any cones which may be punctured or on which the film is gone and refill and charge the arrester.*
5. A sizzling or crackling noise issues from the tanks.	Due to scintillation.	Voltage concentration on any spots in the cell not properly filmed.	This does no real harm unless it is aggravated and becomes the same as symptom 4. No notice need be taken of this symptom.
6. A sizzling or crackling noise issues from some part of the arrester outside the tanks.	Leakage current.	1. Dust or moisture on insulators and resistance units. 2. Cracked or chipped insulators.	1. Clean insulators, frame work and resistance units and remove all traces of moisture. 2. Renew defective insulators.
7. Arcing at points of arrester mechanism other than horns or spheres.	1. Loose or broken connections. 2. Broken ground connection.	1. Carelessness in assembling or due to prolonged arc due to short-circuiting of horns. 2. Corrosion or damage.	1. Repair loose connections and polish all contacts with sand paper and shellac all current carrying parts. 2. Repair break, first cutting the arrester from the line. The arrester is useless and also a hazard when the ground connection is broken, and therefore all ground connections should be periodically inspected and tested. One ground should never be depended upon, two or three being necessary.

* In taking down the stacks of aluminum cell arresters, each cone should be lifted from the wooden supports separately, handling them by the rim only. The contents is emptied out and the cell washed with gasoline or ivory soap, the latter preferred, and thoroughly dried with fine cheese cloth. As each cell or cone is finished it is inverted, with the insulating spacers, which should also be washed and dried, between the cones. In this manner, the cones will occupy the same position when again assembled. The cells when assembled should be immediately filled with electrolyte, to the height called for by the manufacturers, and charged and immediately put in service.

Handy Tables For Use in

Laying Out Wave Windings for A. C. Motors

Complete With Instructions and Worked-Out Examples Showing How the Tables Are Used Together With Details of the Way They Are Derived

THIS IS the third of a series of articles on alternating-current, wave windings. The first two articles, which were published in the September and October issues, explained how to lay out and construct wave windings for three-phase, two-phase, and single-phase stators having two-layer windings. This article gives short-cut methods and tabulations of data for use in laying out this type of winding. A succeeding article will give similar tabulations for use on rotor windings and will also discuss how to lay out wave windings for machines in which the number of slots is not a multiple of the number of poles.

By A. C. ROE

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PREVIOUS articles in the September and October issues explained how to lay out and construct two-layer wave windings for three-phase, two-phase and single-phase stators. We will now take up some of the short-cut methods that may be used to accomplish the same ends with a great deal less time and effort.

After a winder thoroughly understands the principles of wave windings, he will not need a diagram to make the connections. He will be able to figure out the slot in which each lead, short pitch, and reversing jumper will be located, jot down the slot numbers on a sheet of paper and connect up his winding from this data. He will have to use a standard method of connection for all makes of machines, but this will not cause any trouble except where the leads outside the machine are too large to interchange or in the case of machines such as turbo-generators, in which the line leads must have the same relation before and after rewinding. These are in the minority however, and for the general run of cases a standard connection method will prove satisfactory. Consequently, the only things that can affect the winding are: (1) Changing the manner of picking up the leads. (2) Using a left-hand in place of a right-hand winding, or *vice versa*. (3) Connecting the line leads to top conductors in place of the bottom conductors, or *vice versa*. The latter will reverse the direction of rotation in a motor or will change the polarity of the leads in a generator. Interchanging any two leads outside the machine will correct this defect.

In the majority of cases any small changes, such as noted in the preceding paragraph, can be corrected. Therefore a set of tables has been compiled that gives the winding data for a number of standard makes of machines. As each manufacturer has his own method of connecting up a wave winding, one standard method was adopted and used. This standard method will be found satisfactory, unless some very special feature is found in the machine to be rewound.

Tables I to V inclusive given on the following pages are for two-phase, motor windings. Tables VI to X inclusive are for three-phase, motor windings. Table I gives the number of coils from 16 to 216 that will form a balanced two-phase, four-pole winding. The first column gives the number of coils in the winding, the second column gives the coils per section, the third column gives the coils per group, which is also the number of times the winding will be encircled and is equal to the number of series per section, and the fourth column indicates the full front pitch. The fifth, sixth, seventh and eighth columns give the slot numbers in which fall the conductors connecting to the A_1, B_1, A_2, and B_2 leads. The ninth column gives the location of the conductors to which the reversing jumpers are connected. The tenth column gives the location of the conductors which are connected to form the short-pitch connections. The last or eleventh column gives the total number of short jumper clips in the entire winding.

In laying out a winding, the slots should be numbered in a clockwise direction around the stator, if the coils are to be wound in for a left-hand winding. If a right-hand winding is to be laid out, the slots should be numbered around the stator in a counter-clockwise direction. In all of the tables given on the following pages, the A_1 lead is started in slot *1*. Usually the line leads, A_1, A_2, B_1 and B_2 are connected to top conductors. In this case, the reversing jumpers will be connected to bottom conductors. Hence, in the tables, the fifth, sixth, seventh, and eighth columns give the slots which hold the top conductors that the line leads are to be connected to. The ninth column gives the slots holding the bottom conductors which the reversing jumpers are to be connected to. In Table I, for the sixteen-coil winding the bottom conductors of slots *8* and *12* are to be connected together to form one reversing jumper while the bottom conductors in slots *2* and *6* are to be connected together to form the other reversing jumper.

In the short-pitch column, the first figure gives the number of the slot in which a bottom conductor is to be used and the second figure gives the number of the slot in which a top conductor is to be used. These two conductors are connected together for the short-pitch connection. As an example, take the sixteen-coil winding of Table I. In this winding the first short-pitch connection will occur between the bottom conductor in slot *13* and the top conductor in slot *16*; the second short-pitch connection occurs between the bottom conductor in slot *9* and the top conductor in slot *12*, and so on for the other two short-pitch connections. In windings where there are more than two

Table I—Four-Pole, Two-Phase Windings

The following tables give the winding data required for laying out wave windings. If the number of poles, number of phases and number of coils are known, reference to the proper table will give the coils per section, coils per group, winding pitch, and the location of the line leads, star leads, reversing jumpers, and short pitch connections. With this data the winder can connect up the winding without the use of a diagram or other information.

For a left-hand winding number slots in a clockwise direction.

For a right-hand winding number slots in a counter-clockwise direction.

In the last column to the right are given the number of short jumper (S. J.) clips.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Line Leads Top Conductors				Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connected Bottom to Top	No. S. J. Clips
				A_1	B_1	A_2	B_2			
16	4	2	1 & 5	1	11	13	7	(8- 12) (2- 6)	(13-16) (9-12) (7-10) (3-6)	4
24	6	3	1 & 7	1	16	19	10	(11- 17) (2- 8)	(18- 23, 19- 24) (12- 17, 13- 18) (9- 14, 10- 15) (3- 8, 4-9)	8
32	8	4	1 & 9	1	21	25	13	(14- 22) (2-10)	(23- 30, 25- 32) (15- 22, 17- 24) (11- 18, 13- 20) (3-10, 5-12)	12
40	10	5	1 & 11	1	26	31	16	(17- 27) (2-12)	(28- 37, 31- 40) (18- 27, 21- 30) (13- 22, 16- 25) (3-12, 6-15)	16
48	12	6	1 & 13	1	31	37	19	(20- 32) (2-14)	(33- 44, 37- 48) (21- 32, 25- 36) (15- 26, 19- 30) (3-14, 7-18)	20
56	14	7	1 & 15	1	36	43	22	(23- 37) (2-16)	(38- 51, 43- 56) (24- 37, 29- 42) (17- 30, 22- 35) (3-16, 8-21)	24
64	16	8	1 & 17	1	41	49	25	(26- 42) (2-18)	(43- 58, 49- 64) (27- 42, 33- 48) (19- 34, 25- 40) (3-18, 9-24)	28
72	18	9	1 & 19	1	46	55	28	(29- 47) (2-20)	(48- 65, 55- 72) (30- 47, 37- 54) (21- 38, 28- 45) (3-20, 10-27)	32
80	20	10	1 & 21	1	51	61	31	(32- 52) (2-22)	(53- 72, 61- 80) (33- 52, 41- 60) (23- 42, 31- 50) (3-22, 11-30)	36
88	22	11	1 & 23	1	56	67	34	(35- 57) (2-24)	(58- 79, 67- 88) (36- 57, 45- 66) (25- 46, 34- 55) (3-24, 12-33)	40
96	24	12	1 & 25	1	61	73	37	(38- 62) (2-26)	(63- 86, 73- 96) (39- 62, 49- 72) (27- 50, 37- 60) (3-26, 13-36)	44
104	26	13	1 & 27	1	66	79	40	(41- 67) (2-28)	(68- 93, 79-104) (42- 67, 53- 78) (29- 54, 40- 65) (3-28, 14-39)	48
112	28	14	1 & 29	1	71	85	43	(44- 72) (2-30)	(73-100, 85-112) (45- 72, 57- 84) (31- 58, 43- 70) (3-30, 15-42)	52
120	30	15	1 & 31	1	76	91	46	(47- 77) (2-32)	(78-107, 91-120) (48- 77, 61- 90) (33- 62, 46- 75) (3-32, 16-45)	56
128	32	16	1 & 33	1	81	97	49	(50- 82) (2-34)	(83-114, 97-128) (51- 82, 65- 96) (35- 66, 49- 80) (3-34, 17-48)	60
136	34	17	1 & 35	1	86	103	52	(53- 87) (2-36)	(88-121, 103-136) (54- 87, 69-102) (37- 70, 52- 85) (3-36, 18-51)	64
144	36	18	1 & 37	1	91	109	55	(56- 92) (2-38)	(93-128, 109-144) (57- 92, 73-108) (39- 74, 55- 90) (3-38, 19-54)	68
152	38	19	1 & 39	1.	96	115	58	(59- 97) (2-40)	(98-135, 115-152) (60- 97, 77-114) (41- 78, 58- 95) (3-40, 20-57)	72
160	40	20	1 & 41	1	101	121	61	(62-102) (2-42)	(103-142, 121-160) (63-102, 81-120) (43- 82, 61-100) (3-42, 21-60)	76
168	42	21	1 & 43	1	106	127	64	(65-107) (2-44)	(108-149, 127-168) (66-107, 85-126) (45- 86, 64-105) (3-44, 22-63)	80
176	44	22	1 & 45	1	111	133	67	(68-112) (2-46)	(113-156, 133-176) (69-112, 89-132) (47- 90, 67-110) (3-46, 23-66)	84
184	46	23	1 & 47	1	116	139	70	(71-117) (2-48)	(118-163, 139-184) (72-117, 93-138) (49- 94, 70-115) (3-48, 24-69)	88
192	48	24	1 & 49	1	121	145	73	(74-122) (2-50)	(123-170, 145-192) (75-122, 97-144) (51- 98, 73-120) (3-50, 25-72)	92
200	50	25	1 & 51	1	126	151	76	(77-127) (2-52)	(128-177, 151-200) (78-127, 101-150) (53-102, 76-125) (3-52, 26-75)	96
208	52	26	1 & 53	1	131	157	79	(80-132) (2-54)	(133-184, 157-208) (81-132, 105-156) (55-106, 79-130) (3-54, 27-78)	100
216	54	27	1 & 55	1	136	163	82	(83-137) (2-56)	(138-191, 163-216) (84-137, 109-162) (57-110, 81-135) (3-56 28-81)	104

Table II—Six-Pole, Two-Phase Windings

See heading of Table I for instructions on numbering slots.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Line Leads Top Conductors				Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connected Bottom to Top	No. S. J. Clips
				A_1	B_1	A_2	B_2			
24	6	2	1 & 5	1	11	21	7	(16- 20) (2- 6)	(21-24) (17-20) (7-10) (3-6)	4
36	9	3	1 & 7	1	16	31	10	(23- 29) (2- 8)	(30- 35, 31- 36) (24- 29, 25- 30) (9-14, 10-15) (3- 8, 4- 9)	8
48	12	4	1 & 9	1	21	41	13	(30- 38) (2-10)	(39- 46, 41- 48) (31- 38, 33- 40) (11-18, 13-20) (3-10, 5-12)	12
60	15	5	1 & 11	1	26	51	16	(37- 47) (2-12)	(48- 57, 51- 60) (38- 47, 41- 50) (13-22, 16-25) (3-12, 6-15)	16
72	18	6	1 & 13	1	31	61	19	(44- 56) (2-14)	(57- 68, 61- 72) (45- 56, 49- 60) (15-26, 19-30) (3-14, 7-18)	20
84	21	7	1 & 15	1	36	71	22	(51- 65) (2-16)	(66- 79, 71- 84) (52- 65, 57- 70) (17-30, 22-35) (3-16, 8-21)	24
96	24	8	1 & 17	1	41	81	25	(58- 74) (2-18)	(75- 90, 81- 96) (59- 74, 65- 80) (19-34, 25-40) (3-18, 9-24)	28
108	27	9	1 & 19	1	46	91	28	(65- 83) (2-20)	(84-101, 91-108) (66- 83, 73- 90) (21-38, 28-45) (3-20, 10-27)	32
120	30	10	1 & 21	1	51	101	31	(72- 92) (2-22)	(93-112, 101-120) (73- 92, 81-100) (23-42, 31-50) (3-22, 11-30)	36
132	33	11	1 & 23	1	56	111	34	(79-111) (2-24)	(102-123, 111-132) (80-101, 89-110) (25-46, 34-55) (3-24, 12-33)	40
144	36	12	1 & 25	1	61	121	37	(86-120) (2-26)	(111-134, 121-144) (87-110, 97-120) (27-50, 37-60) (3-26, 13-36)	44
156	39	13	1 & 27	1	66	131	40	(93-129) (2-28)	(120-145, 131-156) (94-119, 105-130) (29-54, 40-65) (3-28, 14-39)	48
168	42	14	1 & 29	1	71	141	43	(100-138) (2-30)	(129-156, 141-168) (101-128, 113-140) (31-58, 43-70) (3-30, 15-42)	52
180	45	15	1 & 31	1	76	151	46	(107-147) (2-32)	(138-167, 151-180) (108-137, 121-150) (33-63, 46-75) (3-32, 16-45)	56
192	48	16	1 & 33	1	81	161	49	(114-156) (2-34)	(147-178, 161-192) (115-146, 129-160) (35-66, 49-80) (3-34, 17-48)	60
204	51	17	1 & 35	1	86	171	52	(121-165) (2-36)	(156-189, 171-204) (122-155, 137-170) (37-70, 52-85) (3-36, 18-51)	64
216	54	18	1 & 37	1	91	181	55	(128-174) (2-38)	(165-200, 181-216) (129-164, 145-180) (39-74, 55-90) (3-38, 19-54)	68

Table III—Eight-Pole, Two-Phase Windings

See heading of Table I for instructions on numbering slots.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Line Leads Top Conductors				Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connected Bottom to Top	No. S. J. Clips
				A_1	B_1	A_2	B_2			
32	8	2	1 & 5	1	11	29	7	(24- 28) (2- 6)	(29-32) (25-28) (7-10) (3-6)	4
48	12	3	1 & 7	1	16	43	10	(35- 41) (2- 8)	(42- 47, 43- 48) (36- 41, 37- 42) (9-14, 10-15) (3- 8, 4- 9)	8
64	16	4	1 & 9	1	21	57	13	(46- 54) (2-10)	(55- 62, 57- 64) (47- 54, 49- 56) (11-18, 13-20) (3-10, 5-12)	12
80	20	5	1 & 11	1	26	71	16	(57- 67) (2-12)	(68- 77, 71- 80) (58- 67, 61- 70) (13-22, 16-25) (3-12, 6-15)	16
96	24	6	1 & 13	1	31	85	19	(68- 80) (2-14)	(81- 92, 85- 96) (69- 80, 73- 84) (15-26, 19-30) (3-14, 7-18)	20
112	28	7	1 & 15	1	36	99	22	(79- 93) (2-16)	(94-107, 99-112) (80- 93, 85- 98) (17-30, 22-35) (3-16, 8-21)	24
128	32	8	1 & 17	1	41	113	25	(90-106) (2-18)	(107-122, 113-128) (91-106, 97-112) (19-34, 25-40) (3-18, 9-24)	28
144	36	9	1 & 19	1	46	127	28	(101-119) (2-20)	(120-137, 127-144) (102-119, 109-126) (21-38, 28-45) (3-20, 10-27)	32
160	40	10	1 & 21	1	51	141	31	(112-132) (2-22)	(133-152, 141-160) (113-132, 121-140) (23-42, 31-50) (3-22, 11-30)	36
176	44	11	1 & 23	1	56	155	34	(123-145) (2-24)	(146-167, 155-176) (124-145, 133-154) (25-46, 34-55) (3-24, 12-33)	40
192	48	12	1 & 25	1	61	169	37	(134-158) (2-26)	(159-182, 169-192) (135-158, 145-168) (27-50, 37-60) (3-26, 13-36)	44
208	52	13	1 & 27	1	66	183	40	(145-171) (2-28)	(172-197, 183-208) (146-171, 167-182) (29-54, 40-65) (3-28, 14-39)	48
224	56	14	1 & 29	1	71	197	43	(156-184) (2-30)	(185-212, 197-224) (157,184, 179-196) (31-58, 43-70) (3-30, 15-42)	52

short-pitch connections, the slot numbers of the first and last short-pitch connections are given. For the thirty-two-coil winding in the third line of Table I, there appears in the tenth or short-pitch column, a group of four figures in brackets, the first group being (*23-30, 25-32*). This means that the bottom conductors in slots *23, 24* and *25* are to be connected to the top conductors in slots *30, 31* and *32* respectively; that is, the bottom conductor in slot *23* is to be connected to the top conductor in slot *30*, the bottom conductor in slot *24* is to be connected to the top conductor in slot *31*, and the bottom conductor in slot *25* is to be connected to the top conductor in slot *32*. This method saves time and space in compiling the tables.

Tables VI to X are for three-phase windings, having from four to twelve poles and connected series star or series delta. In these tables, the line leads and the star connections are the top conductors in the slots indicated in the fifth, sixth, seventh, eighth, ninth, and tenth columns. The line leads are designated by A, B and C; the star connections are indicated by A_1, B_1 and C_1. The tables give the arrangements direct for a series-star connection; that is, for the twenty-four-coil winding in Table VI, the line leads connect to the top conductors in slots *1, 9* and *17* respectively, and the star connection is formed by joining together the top conductors in slots *19, 3* and *11*. If a series-delta connection for the same winding is desired, the connection scheme is given at the top of Table VI. The leads A and B_1 connect to one line, the leads B and C_1 connect to the next line and the leads C and A_1 connect to the third line. That is, the top conductors in slots *1* and *3* connect to one line, the top conductors of slots *9* and *11* connect to the second line, and the top conductors in slots *17* and *19* connect to the third line.

The winding layout given in the table will bring the line leads close together. A method of figuring the layout for other spacings will be given later. The precautions necessary when laying out the winding in the motor are: first, that the slots be numbered in a clockwise direction for a left-hand winding and in a counter-clockwise direction for a right-hand winding; and second, that the winder face the connection end of the stator when laying out the slot numbers and when determining whether the winding is to be right hand or left hand.

These tables apply to right- and left-hand windings having the leads connected to top conductors. The tables can also be used when it is desired to use the bottom conductors for leads. For a left-hand winding in which bottom conductors are connected to the line leads, the slots should be numbered in a counter-clockwise direction. Then instead of taking the top conductors in the slots indicated in the table for the line and star leads, use the bottom conductors in the same slots. The reversing jumpers will be connected to top conductors instead of bottom conductors and will use the same slots as the table shows. For the short-pitch connections, it is only necessary to change the tables to read top to bottom, instead of bottom to top. For example, in the first line (twenty-four-coil winding) of Table VI, the first short-pitch connection will occur between the top conductor of slot *19* and the bottom conductor of slot *24* instead of the bottom conductor of slot *19* and the top conductor of slot *24*, as the table reads.

If it is desired to use bottom conductors for line leads and have a right-hand winding, the slots should be numbered in a clockwise direction. The line leads will be connected to bottom conductors, the reversing jumpers will be connected to top conductors and the short-pitch connections will be the same as has been

Table IV—Ten-Pole, Two-Phase Windings

See heading of Table I for instructions on numbering slots.

No. of Coils	Coils per Section	Coils per Group	Pitch	Line Leads Top Conductors				Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connected Bottom to Top	No. S. J. Clips
				A_1	B_1	A_2	B_2			
20	5	1	1 & 3	1	6	19	4	(17-19) (2-4)	None	0
40	10	2	1 & 5	1	11	37	7	(32-36) (2-6)	(37-40) (33-36) (7-10) (3-6)	4
60	15	3	1 & 7	1	16	55	10	(47-53) (2-8)	(54-59, 55-60) (48-53, 49-54) (9-14, 10-15) (3-8, 4-9)	8
80	20	4	1 & 9	1	21	73	13	(62-70) (2-10)	(71-78, 73-80) (63-70, 65-72) (11-18, 13-20) (3-10, 5-12)	12
100	25	5	1 & 11	1	26	91	16	(77-87) (2-12)	(88-97, 91-100) (78-87, 81-90) (13-22, 16-25) (3-12, 6-15)	16
120	30	6	1 & 13	1	31	109	19	(92-104) (2-14)	(105-116, 109-120) (93-104, 97-108) (15-26, 19-30) (3-14, 7-18)	20
140	35	7	1 & 15	1	36	127	22	(107-121) (2-16)	(122-135, 127-140) (108-121, 113-126) (17-30, 22-35) (3-16, 8-21)	24
160	40	8	1 & 17	1	41	145	25	(122-138) (2-18)	(139-154, 145-160) (123-138, 129-144) (19-34, 25-40) (3-18, 9-24)	28
180	45	9	1 & 19	1	46	163	28	(137-155) (2-20)	(156-173, 163-180) (138-155, 145-162) (21-38, 28-45) (3-20, 10-27)	32
200	50	10	1 & 21	1	51	181	31	(152-172) (2-22)	(173-192, 181-200) (153-172, 161-180) (23-42, 31-50) (3-22, 11-30)	36
220	55	11	1 & 23	1	56	199	34	(167-189) (2-24)	(190-211, 199-220) (168-189, 177-198) (25-46, 34-55) (3-24, 12-33)	40

Table V—Twelve-Pole, Two-Phase Windings

See heading of Table I for instructions on numbering slots.

No. of Coils	Coils per Section	Coils per Group	Pitch	Line Leads Top Conductors				Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connected Bottom to Top	No. S. J. Clips
				A_1	B_1	A_2	B_2			
24	6	1	1 & 3	1	6	23	4	(21-23) (2-4)	None	0
48	12	2	1 & 5	1	11	45	7	(40-44) (2-6)	(45-48) (41-44) (7-10) (3-6)	4
72	18	3	1 & 7	1	16	67	10	(59-65) (2-8)	(66-71, 67-72) (60-65, 61-66) (9-14, 10-15) (3-8, 4-9)	8
96	24	4	1 & 9	1	21	89	13	(78-86) (2-10)	(87-94, 89-96) (79-86, 81-88) (11-18, 13-20) (3-10, 5-12)	12
120	30	5	1 & 11	1	26	111	16	(97-107) (2-12)	(108-117, 111-120) (98-107, 101-110) (13-22, 16-25) (3-12, 6-15)	16
144	36	6	1 & 13	1	31	133	19	(116-128) (2-14)	(129-140, 133-144) (117-128, 121-132) (15-26, 19-30) (3-14, 7-18)	20
168	42	7	1 & 15	1	36	155	22	(135-149) (2-16)	(150-163, 155-168) (136-149, 141-154) (17-30, 22-35) (3-16, 8-21)	24
192	48	8	1 & 17	1	41	177	25	(154-170) (2-18)	(171-186, 177-192) (155-170, 161-176) (19-34, 25-40) (3-18, 9-24)	28
216	54	9	1 & 19	1	46	199	28	(173-191) (2-20)	(192-209, 199-216) (174-191, 181-198) (21-38, 28-45) (3-20, 10-27)	32

outlined in the preceding paragraph.

The way to apply the data given in the tables direct to the winding, without the use of a diagram, is as follows:

(1) Locate the slot that is on the center line of the terminal block. Call this the B-phase, line-lead slot.

(2) The tables will give the number of the B-phase, line-lead slot and using this as a starting point, all of the other slots can be numbered.

(3) The coils should now be put in the stator in the proper group formation. The first and last coils of each group are phase coils and should have phase insulation. The number of coils in a group is given in the third column of the table; hence the location of the phase coils can be readily determined.

(4) Locate the conductors to which the line leads and star leads connect. This is given in the tables.

(5) Locate the reversing jumpers and tie them together temporarily. The location of the slots in which the reversing jumpers fall is given in the tables.

(6) Locate the conductors forming each of the short pitches in the order given in the table. Clip these

Table VI—Four-Pole, Three-Phase Windings

These tables give the arrangement for a series-star connection. To obtain a series-delta connection, connect A and B_1 to one line lead, B and C_1 to second line lead and C and A_1 to third line lead.
For a left-hand winding number slots in a clockwise direction.
For a right-hand winding number slots in a counter-clockwise direction.
"Top" refers to top conductor in slot; "bottom" refers to bottom conductor in slot.
In the last column to the right are given the number of short jumper (S. J.) clips.
Tables VI-X give layouts that will bring the line leads as close together as possible.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top			Star Top			Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top	No. S. J. Clips
				A	B	C	A_1	B_1	C_1			
24	4	2	1 & 7	1	9	17	19	3	11	(12- 18)(20-2)(4-10)	(19-24) (13-18) (3-8) (21-2) (11-16) (5-10)	6
36	6	3	1 & 10	1	13	25	28	4	16	(17- 26)(29-2)(5-14)	(27- 35, 28- 36)(18- 26, 19- 27)(3-11, 4-12)(30-2, 31- 3)(15- 23, 16- 24)(6-14, 7-15)	12
48	8	4	1 & 13	1	17	33	37	5	21	(22- 34)(38-2)(6-18)	(35- 46, 37- 48)(23- 34, 25- 36)(3-14, 5-16)(39-2, 41- 4)(19- 30, 21- 32)(7-18, 9-20)	18
60	10	5	1 & 16	1	21	41	46	6	26	(27- 42)(47-2)(7-22)	(43- 57, 46- 60)(28- 42, 31- 45)(3-17, 6-20)(48-2, 51- 5)(23- 37, 26- 40)(8-22, 11-25)	24
72	12	6	1 & 19	1	25	49	55	7	31	(32- 50)(56-2)(8-26)	(51- 68, 55- 72)(33- 50, 37- 54)(3-20, 7-24)(57-2, 61- 6)(27- 44, 31- 48)(9-26, 13-30)	30
84	14	7	1 & 22	1	29	57	64	8	36	(37- 58)(65-2)(9-30)	(59- 79, 64- 84)(38- 58, 43- 63)(3-23, 8-28)(66-2, 71- 7)(31- 51, 36- 56)(10-30, 15-35)	36
96	16	8	1 & 25	1	33	65	73	9	41	(42- 66)(74-2)(10-34)	(67- 90, 73- 96)(43- 66, 49- 72)(3-26, 9-32)(75-2, 81- 8)(35- 58, 41- 64)(11-34, 17-40)	42
108	18	9	1 & 28	1	37	73	82	10	46	(47- 74)(83-2)(11-38)	(75-101, 82-108)(48- 74, 55- 81)(3-29, 10-36)(84-2, 91- 9)(39- 65, 46- 72)(12-38, 19-45)	48
120	20	10	1 & 31	1	41	81	91	11	51	(52- 82)(92-2)(12-42)	(83-112, 91-120)(53- 82, 61- 90)(3-32, 11-40)(93-2, 101-10)(43- 72, 51- 80)(13-42, 21-50)	54
132	22	11	1 & 34	1	45	89	100	12	56	(57- 90)(101-2)(13-46)	(91-123, 100-132)(58- 90, 67- 99)(3-35, 12-44)(102-3, 111-11)(47- 79, 56- 88)(14-46, 23-55)	60
144	24	12	1 & 37	1	49	97	109	13	61	(62- 98)(110-2)(14-50)	(99-134, 109-144)(63- 98, 73-108)(3-38, 13-48)(111-2, 121-12)(51- 86, 61- 96)(15-50, 25-60)	66
156	26	13	1 & 40	1	53	105	118	14	66	(67-106)(119-2)(15-54)	(107-145, 118-156)(68-106, 79-117)(3-41, 14-52)(120-2, 131-13)(55- 93, 66-104)(16-54, 27-65)	72
168	28	14	1 & 43	1	57	113	127	15	71	(72-114)(128-2)(16-58)	(115-156, 127-168)(73-114, 85-126)(3-44, 15-56)(129-2, 141-14)(59-100, 71-112)(17-58, 29-70)	78
180	30	15	1 & 46	1	61	121	136	16	76	(77-122)(137-2)(17-62)	(123-167, 136-180)(78-122, 91-135)(3-47, 16-60)(138-2, 151-15)(63-107, 76-120)(18-62, 31-75)	84
192	32	16	1 & 49	1	65	129	145	17	81	(82-130)(146-2)(18-66)	(131-178, 145-192)(83-130, 97-144)(3-50, 17-64)(147-2, 161-16)(67-114, 81-128)(19-66, 33-80)	90
204	34	17	1 & 52	1	69	137	154	18	86	(87-138)(155-2)(19-70)	(139-189, 154-204)(88-138, 103-153)(3-53, 18-68)(156-2, 171-17)(71-121, 86-136)(20-70, 35-85)	96
216	36	18	1 & 55	1	73	145	163	19	91	(92-146)(164-2)(20-74)	(147-200, 163-216)(93-146, 109-162)(3-56, 19-72)(165-2, 181-18)(75-128, 91-144)(21-74, 37-90)	102

Table VII—Six-Pole, Three-Phase Windings

See heading of Table VI for instructions on using table.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top			Star Top			Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top	No. S. J. Clips
				A	B	C	A_1	B_1	C_1			
18	3	1	1 & 4	1	5	9	16	2	6	(13- 16) (17-2) (3- 6)	None	0
36	6	2	1 & 7	1	9	17	31	3	11	(24- 30) (32-2) (4-10)	(31-36) (25-30) (3-8) (33-2) (11-16) (5-10)	6
54	9	3	1 & 10	1	13	25	36	4	16	(35- 44) (47-2) (5-14)	(45- 53, 46- 54) (26-34, 27-35) (3-11, 4-12) (48-2, 49- 3) (15-23, 16-24) (6-14, 7-15)	12
72	12	4	1 & 13	1	17	33	41	5	21	(46- 58) (62-2) (6-18)	(59- 70, 61- 72) (27-38, 29-40) (3-14, 5-16) (63-2, 65- 4) (19-30, 21-32) (7-18, 9-20)	18
90	15	5	1 & 16	1	21	41	46	6	26	(57- 72) (77-2) (7-22)	(73- 87, 76- 90) (28-42, 31-45) (3-17, 6-20) (78-2, 81- 5) (23-37, 26-40) (8-22, 11-25)	24
108	18	6	1 & 19	1	25	49	51	7	31	(68- 86) (92-3) (8-26)	(87-104, 91-108) (29-46, 33-50) (3-20, 7-24) (93-2, 97- 6) (27-44, 31-48) (9-26, 13-30)	30
126	21	7	1 & 22	1	29	57	56	8	36	(79-100) (107-2) (9-30)	(101-121, 106-126) (30-50, 35-55) (3-23, 8-28) (108-2, 113- 7) (31-51, 36-56) (10-30, 15-35)	36
144	24	8	1 & 25	1	33	65	61	9	41	(90-114) (122-2) (10-34)	(115-138, 121-144) (31-54, 37-60) (3-26, 9-32) (123-2, 129- 8) (35-58, 41-64) (11-34, 17-40)	42
162	27	9	1 & 28	1	37	73	66	10	46	(101-128) (137-2) (11-38)	(129-155, 136-162) (32-58, 39-65) (3-29, 10-36) (138-2, 145- 9) (39-65, 46-72) (12-38, 19-45)	48
180	30	10	1 & 31	1	41	81	71	11	51	(112-142) (152-2) (12-42)	(143-172, 151-180) (33-62, 41-70) (3-32, 11-40) (153-2, 161-10) (43-73, 51-80) (13-42, 21-50)	54
198	33	11	1 & 34	1	45	89	76	12	56	(123-156) (167-2) (13-46)	(157-189, 166-198) (34-66, 43-75) (3-35, 12-44) (168-2, 177-11) (47-79, 56-88) (14-46, 23-55)	60
216	36	12	1 & 37	1	49	97	81	13	61	(134-170) (182-2) (14-50)	(171-206, 181-216) (35-70, 45-80) (3-38, 13-48) (183-2, 193-12) (51-86, 61-96) (15-50, 25-60)	66

Table VIII—Eight-Pole, Three-Phase Windings

See heading of Table VI for instructions on using table.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top			Star Top			Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top	No. S. J. Clips
				A	B	C	A_1	B_1	C_1			
24	4	1	1 & 4	1	5	9	22	2	6	(19- 22) (23-2) (3- 6)	None	0
48	8	2	1 & 7	1	9	17	43	3	11	(36- 42) (44-2) (4-10)	(43-48) (37-42) (3-8) (45-2) (11-16) (5-10)	6
72	12	3	1 & 10	1	13	25	64	4	16	(53- 62) (65-2) (5-14)	(63- 71, 64- 72)(54- 62, 55- 63)(3-11, 4-12)(66-2, 67- 3)(15-23, 16-24)(6-14, 7-15)	12
96	16	4	1 & 13	1	17	33	85	5	21	(70- 82) (86-2) (6-18)	(83- 94, 85- 96)(71- 82, 73- 84)(3-14, 5-16)(87-2, 89- 4)(19-30, 21-32)(7-18, 9-20)	18
120	20	5	1 & 16	1	21	41	106	6	26	(87-102) (107-2) (7-22)	(103-117, 106-120)(88-102, 91-105)(3-17, 6-20)(108-2, 111- 5)(23-37, 26-40)(8-22, 11-25)	24
144	24	6	1 & 19	1	25	49	127	7	31	(104-122) (128-2) (8-26)	(123-140, 127-144)(105-122, 109-126)(3-20, 7-24)(129-2, 133- 6)(27-44, 31-48)(9-26, 13-30)	30
168	28	7	1 & 22	1	29	57	148	8	36	(121-142) (149-2) (9-30)	(143-163, 148-168)(122-142, 127-147)(3-23, 8-28)(150-2, 155- 7)(31-51, 36-56)(10-30, 15-35)	36
192	32	8	1 & 25	1	33	65	169	9	41	(138-162) (170-2) (10-34)	(163-186, 169-192)(139-162, 145-168)(3-26, 9-32)(171-2, 177- 9)(35-58, 41-64)(11-34, 17-40)	42
216	36	9	1 & 28	1	37	73	190	10	46	(155-182) (191-2) (11-38)	(183-209, 190-216)(156-182, 163-189)(3-29 10-36)(192-2, 199- 9)(39-65, 46-72)(12-38, 19-45)	48
240	40	10	1 & 31	1	41	81	211	11	51	(172-202) (212-2) (12-42)	(203-232, 211-240)(173-202, 181-210)(3-32, 11-40)(213-2, 221-10)(43-72, 51-80)(13-42, 21-50)	54

These Rules for Laying Out Wave Windings Were Derived in the First Two Articles of this Series

Rule 1—The number of coils in a series is equal to one-half the number of poles in the winding.

Rule 2—The number of series of coils equals the number of slots per pole per phase, which is equal to the number of slots divided by the number of poles and this result divided by the number of phases.

Rule 3—The number of sections equals twice the number of phases; that is, each phase will have two sections.

Rule 4—The number of coil groups is equal to the number of poles multiplied by the number of phases.

Rule 5—Between the starting and finishing leads of each section there will occur a number of short pitches equal to one less than the number of slots per pole per phase.

Rule 6—The reversing jumper lead (that is, R_1, R_2, R_3, R_4, R_5, etc.) and the finishing lead of the phases (that is, A_2, B_2, C_2) are on the left of their respective phase starting lead (that is, A_1, B_1, C_1), for a left-hand winding and on the right for a right-hand winding.

Rule 7—The first reversing jumper of a phase (that is, R_1 for A phase, R_3 for B phase, or R_5 for C phase) will be located in a slot that is a number of slots from the phase starting slot (A_1, B_1, or C_1, as the case may be) equal to the front pitch plus one less than the number of coils per group, measured in a counter-clockwise direction for a left-hand winding and measured in a clockwise direction for a right-hand winding. Also, if the starting lead (A_1, B_1, or C_1) goes to a top conductor, then the reversing jumper lead is connected to a bottom conductor.

Rule 8—The second reversing jumper lead for a given phase (R_2, R_4, or R_6) is connected to a bottom coil half or conductor when the first reversing jumper is connected to a bottom conductor and *vice versa*, and is spaced one front pitch measured in a counter-clockwise direction from the first reversing jumper for a left-hand winding and measured in a clockwise direction for a right-hand winding.

Rule 9—The finishing lead of a phase (A_2, B_2, or C_2), will connect to a conductor located in a slot that is one front pitch from the starting lead of that phase and is measured in a counter-clockwise direction for a left-hand winding and in a clockwise direction for a right-hand winding.

Rule 10—If the starting lead of a phase connects to a top conductor or coil half, then the finishing lead of that phase will connect to a top conductor, or *vice versa.*

Rule 11—In a left-hand winding having more than one coil per cell and in which the line leads are to be connected to top conductors, the line leads must connect to the top conductors on the right-hand side of the slot, while the reversing jumpers connect to bottom conductors on the left-hand side of the slot. When the line leads connect to bottom conductors, the bottom conductors on the left-hand side of the slot must be used and the reversing jumpers will connect to top conductors on the right-hand side of the slot. The opposite holds true for a right-hand winding; that is, with line leads connecting to top conductors, use left-hand top conductors, and the reversing jumpers will connect to right-hand bottom conductors. Also, if the line leads connect to bottom conductors, use right-hand bottom conductors for line leads and connect the reversing jumpers to left-hand top conductors.

Rule 12—When there is more than one coil per cell, we pass completely around the winding as many times as there are conductors or coil sides per cell before we use the short front pitch.

conductors together as fast as they are located.

(7) Locate, by means of a test light, the other coil half or conductor of the coil to which the A-phase line lead is connected. Also, locate the top conductor that is two back pitches measured in the same direction the slots are numbered, from the conductor to which the A-phase line lead connects. This will locate the second coil of the first series. These two conductors should be clipped together. Using this as a starting point, clip the unconnected adjacent top and bottom conductors together all around the winding.

As an example of how the tables are to be used, let us lay out a left-hand, two-layer, winding for a four-pole, two-phase motor, having twenty-four coils and twenty-four slots. The first thing to do is to locate the slot that is on the center line of the terminal block. In Fig. 1 on page 555 assume that this is the slot marked X.

This is the slot for the B_1 lead. In Table I on the second line, which is for a twenty-four-coil winding, we find that the B_1 lead falls in slot *16*; hence we are able to number the slots in the manner shown in the diagram. Since the winding is to be left hand, the slots should be numbered in a clockwise direction. The winder should face the connection side of the stator when marking the numbers on the slots.

The coils should now be put in the stator in the proper group formation. According to the table, there are three coils per group; hence the first and third or last coil of each group should have phase insulation.

The conductors to which the line leads connect, should be located next. According to the table, they are all top conductors and are located in the following slots: A_1 in slot *1*, B_1 in slot *16*, A_2 in slot *19* and B_2 in slot *10*. This is shown in detail in Fig. 1 on page 555.

The reversing jumpers should now be located and tied together temporarily. According to Table I, one reversing jumper should connect the bottom conductors in slots *11* and *17* together (R_1 to R_2 in Fig. 1) and the other reversing jumper should connect the bottom conductors in slots *2* and *8* (R_3 to R_4 in Fig. 1).

The short-pitch connections should be located next. According to the table, the first short-pitch connection occurs between the bottom conductor in slot *18* and the top conductor in slot *23*; the second short-pitch connection occurs between the bottom conductor in slot *19* and the top conductor in slot *24*, and so on through the remaining six short-pitch connections. The short-pitch connections are indicated in Fig. 1 by the asterisks. These conductors should be connected together as fast as they are located.

By means of a test light, locate the second conductor of the coil to which the A-phase, line lead connects. The A-phase, line lead connects to the top conductor in slot *1*. By the test light, we find that the other coil side or conductor of this coil (coil *a1*) is the bottom conductor in slot *7*. This conductor is to be connected to the top conductor two full back pitches from slot *1* measured in the same direction in which the slots are numbered. This second conductor will fall in slot *13*. Using this as a starting point, clip together in a similar manner the remaining, unconnected adjacent top and bottom conductors.

After the rules for wave windings are understood, it is a simple matter to arrange a winding table for any number of coils, phases, and poles. In constructing such a winding table, there are several things about the winding that must be known at the start. They are: the number of phases; the number of poles; the number of slots; the number of coils; whether the winding is to be right hand or left hand; and whether the leads are to connect to top or bottom conductors in the slots. As an example, let us calculate the winding data for a two-phase, four-

Table IX—Ten-Pole, Three-Phase Windings

See heading of Table VI for instructions on using table.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top			Star Top			Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top	No. S. J. Clips
				A	B	C	A1	B1	C1			
30	5	1	1 & 4	1	5	9	28	2	6	(25- 28) (29-2) (3- 6)	None	0
60	10	2	1 & 7	1	9	17	55	3	11	(48- 54) (56-2) (4-10)	(55-60) (49-54) (3-8) (57-2) (11-16) (5-10)	6
90	15	3	1 & 10	1	13	25	82	4	16	(71- 80) (83-2) (5-14)	(81- 89, 82- 90)(72- 80, 73- 81)(3-11, 4-12)(84-2, 85-3)(15-23, 16-24)(6-14, 7-15)	12
120	20	4	1 & 13	1	17	33	109	5	21	(94-106) (110-2) (6-18)	(107-118, 109-120)(95-106, 97-108)(3-14, 5-16)(111-2, 113-4)(19-30, 21-32)(7-18, 9-20)	18
150	25	5	1 & 16	1	21	41	136	6	26	(117-132) (137-2) (7-22)	(133-147, 136-150)(118-132, 121-135)(3-17, 6-20)(138-2, 141-5)(23-37, 26-40)(8-22, 11-25)	24
180	30	6	1 & 19	1	25	49	163	7	31	(140-158) (164-2) (8-26)	(159-176, 163-180)(141-158, 145-162)(3-20, 7-24)(165-2, 169-6)(27-44, 31-48)(9-26, 13-30)	30
210	35	7	1 & 22	1	29	57	190	8	36	(163-184) (191-2) (9-30)	(185-205, 190-210)(164-184, 169-189)(2-23, 8-28)(192-2, 197-7)(31-51, 36-56)(10-30, 15-35)	36
240	40	8	1 & 25	1	33	65	217	9	41	(186-210) (218-2) (10-34)	(211-234, 217-240)(187-210, 193-216)(3-26, 9-32)(219-2, 225-8)(35-58, 41-64)(11-34, 17-40)	42

Table X—Twelve-Pole, Three-Phase Windings

See heading of Table VI for instructions on using table.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top			Star Top			Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top	No. S. J. Clips
				A	B	C	A1	B1	C1			
36	6	1	1 & 4	1	5	9	34	2	6	(31- 34) (35-2) (3- 6)	None	0
72	12	2	1 & 7	1	9	17	67	3	11	(60- 66) (68-2) (4-10)	(67-72) (61-66) (3-8) (69-2) (11-16) (5-10)	6
108	18	3	1 & 10	1	13	25	100	4	16	(89- 98) (101-2) (5-14)	(99-107, 100-108)(90- 98, 91 - 99)(3-11, 4-12)(102-2, 103-3)(15-23, 16-24)(6-14, 7-15)	12
144	24	4	1 & 13	1	17	33	133	5	21	(118-130) (134-2) (6-18)	(131-142, 133-144)(119-130, 121-132)(3-14, 5-16)(135-2, 137-4)(19-30, 21-32)(7-18, 9-20)	18
180	30	5	1 & 16	1	21	41	166	6	26	(147-162) (167-2) (7-22)	(163-177, 166-180)(148-162, 151-165)(3-17, 6-20)(168-2, 171-5)(23-37, 26-40)(8-22, 11-25)	24
216	36	6	1 & 19	1	25	49	199	7	31	(176-194) (200-2) (8-26)	(195-212, 199-216)(177-194, 181-198)(3-20, 7-24)(201-2, 205-6)(27-44, 31-48)(9-26, 13-30)	30
252	42	7	1 & 22	1	29	57	232	8	36	(205-226) (233-2) (9-30)	(227-247, 232-252)(206-226, 211-231)(3-23, 8-28)(234-2, 239-7)(31-51, 36-56)(10-30, 15-35)	36
288	48	8	1 & 25	1	33	65	265	9	41	(234-258) (266-2) (10-34)	(259-282, 265-288)(235-258, 241-264)(3-26, 9-32)(267-2, 273-8)(35-58, 41-64)(11-34, 17-40)	42

pole, stator having thirty-two slots and coils and having the line leads connected to top conductors in the slots. The winding is to be left hand. The data and calculation will be tabulated as follows:

(1) Number of slots—32.
(2) Number of phases—2.
(3) Number of poles—4.
(4) Number of coils—32.
(5) Number of sections, according to *Rule 3* (given in the box on page 536) is equal to $2 \times 2 = 4$.
(6) Number of coil groups according to *Rule 4*, equals $2 \times 4 = 8$.
(7) Number of coils per section equals total number of coils divided by the total number of sections, or $32 \div 4 = 8$. This checks with the value given in the third line and second column of Table I.
(8) Number of coils per group equals total number of coils divided by the number of coil groups, or $32 \div 8 = 4$. This gives the value given in the third line and third column of Table I.
(9) According to *Rule 5*, there will occur in each section a number of short-pitch connections equal to one less than the number of slots per pole per phase; that is, there will be a number of short-pitch connections equal to $[(32 \div 4) \div 2] - 1 = 3$.
(10) The total winding pitch equals total number of slots divided by half the number of poles, or $32 \div 2 = 16$; that is the total winding pitch will be 1-and-17.
(11) The back pitch is equal to one half of the winding pitch, or $16 \div 2 = 8$, which is a back pitch of 1-and-9.
(12) The front pitch is equal to the total winding pitch minus the back pitch, or $16 - 8 = 8$, which is a front pitch of 1-and-9. Items 11 and 12 check the value given in the third line and fourth column of Table I.
(13) The pick-up pitch is used in locating the conductor which is the end of the first section of a phase; that is, it is the conductor from which the reversing jumper starts. According to *Rule 7*, this conductor is located in a slot that is a number of slots from the phase-starting slot equal to the front pitch plus one less than the number of coils per group. Consequently, the pick-up pitch equals $8 + 4 - 1 = 11$; that is, a pick-up pitch of 1-and-12.
(14) The short pitch is equal to one slot less than the front pitch; that is, it is equal to $8 - 1 = 7$, or a pitch of 1-and-8.
(15) As we have said before in this article the A_1 lead will connect to a conductor in slot *1*. It could go into any other slot, but for simplicity in laying out the winding, we will locate it in slot *1*. We have decided at the start of this calculation that the winding is to be left-hand and that the leads are to go to top conductors; therefore, the A_1 lead will connect to the top conductor in slot *1*. This is the slot number given in the third line and fifth column of Table I.
(16) The A_2 lead will connect to a top conductor that is in a slot one back pitch measured in a counter-clockwise direction from the A_1 slot. Since the A_1 lead connects to a conductor in slot *1* and since there are thirty-two slots in this stator, slot *1* is the equivalent of slot *33* and, therefore, the A_2 lead will be found as follows: $33 - 8 = 25$. The A_2 lead will connect to the top conductor in slot *25*, which is the slot number given in the third line, seventh column of Table I. This is in accordance with *Rule 9*.
(17) The conductor to which the B_1 lead connects will be a number of slots measured in a clockwise direction from the A_1 slot (slot *1*) equal to two times the front pitch plus the number of coils per group. Therefore, the conductor to which the B_1 lead connects will fall in $1 + (2 \times 8) + 4 = 21$, or slot *21*. This checks the slot number given in the third line, sixth column of Table I.
(18) According to *Rule 9*, the conductor to which the B_2 lead connects will fall in a slot that is one front pitch measured in a counter-clockwise direction from the B_1 slot; that is, $21 - 8 = 13$. Therefore, the conductor to which the B_2 lead will connect falls in slot *13*. According to *Rule 10* it will connect to a top conductor in that slot. This checks the slot number given in the third line, eighth column of Table I.
(19) As said before in this article and in accordance with *Rule 7*, the R_1 lead will fall in a slot that is one pick-up pitch measured in a counter-clockwise direction from the A_1 slot; that is, slot *1*, or, what is equivalent to it, slot *33*. The pick-up pitch is 11; then $33 - 11 = 22$; consequently, the R_1 lead will connect to a bottom conductor in slot *22*.
(20) According to *Rule 8*, the second reversing-jumper lead for a given phase in a left-hand winding will fall one front pitch measured in a counter-clockwise direction from the first reversing-jumper lead, or $22 - 8 = 14$. Therefore, the R_2 lead will connect to a conductor that is located in the bottom of slot *14*.
(21) In a manner similar to that used in item 19, we find that the R_3 lead will connect to a bottom conductor in slot *10*, for the B_1 lead falls in slot *21* and the pick-up pitch is equal to *11*, and $21 - 11 = 10$.
(22) In a manner similar to that used in item 20, we find that R_4 falls in the bottom of slot *2*, for the R_3 conductor falls in slot *10* and the front pitch is equal to 8; then $10 - 8 = 2$. The slot numbers given in items 19, 20, 21 and 22 check the data given in the third line, ninth column of Table I.

If we examine Fig. 1 we will notice that there are two short-pitch connections that start from slots that are located (*Continued on page 554*)

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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Assisted by
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Chicago, November, 1924

Know What Material Handling Actually Costs

ONE of the most difficult problems incidental to persuading industrial men to change the method of performing any operation lies in convincing them that the new way is the better way. This is particularly true in material handling. Here traditional practices of carrying materials on two-wheeled hand trucks or by methods unsuited, in the light of modern developments, to the conditions of load and distance, are still altogether too common.

This work has been performed largely by common labor. In the United States it has always been easy to hire this labor whenever needed and to fire it when conditions were such that it was no longer required. Many industrial men have come to believe that this is the cheapest and best way of handling the situation.

Due to the present order of things, particularly the tightening up of immigration, this privilege of hiring and firing is past. Many concerns continue to attempt this method and when they learn that they cannot secure proper labor they still hesitate about substituting mechanical methods of handling material because of the apparently high first cost. This cost, in spite of their opinion, is today not sufficiently high to give the desired return in proportion to the risk and engineering necessary to carry on the development of new types of equipment to meet the demands of economical handling, and also to cover the expense of missionary work in persuading the prospective user of its advantages.

Probably the prime reason for all this is that trucking has usually been considered as a non-productive operation. These costs have crept into the general overhead and no real record has ever been maintained, so that the employer of labor has had no real knowledge of the actual expense attached to the handling of material in process. Naturally, therefore, in making a capital expenditure, such as he is called upon to authorize in the purchase of equipment, this operation is next put on the productive schedule, and even though the saving be great, it is very difficult to learn exactly what it is, due to lack of proper cost keeping for the hand operation. Thus he has no actual figures for comparison.

Those industrial men who are faced with the problem of revamping their material-handling methods will find it to their advantage to first make a careful analysis of what is done and how much it costs. This will provide the basis for a study of new methods and equipment available and a check on their performance.

He Cannot Read His Tombstone When He's Dead

FOR what follows we would like to have the ear of employers. We recently had our attention called to an advertisement eulogizing an employee who had died after twenty years of faithful service. This was a nice touch of sentiment for an association of two decades, but the unfortunate fact about it is that it came too late. The heirs and assigns probably read that advertisement with much satisfaction, but the man who was moved, by an unquestionably high motive, to spend the company's money in this way forgot that his associate could not read his tombstone when he's dead.

A tangible token of appreciation for faithful service during a man's lifetime would cost no more than a newspaper advertisement and there can not be the least doubt that such recognition to a living worker is worth more to all concerned than a newspaper full of eulogizing advertisements dedicated to dead ones.

Some organizations have adopted a service emblem that is a mark of special recognition worn by men who for definite and known reasons merit it. It is not a substitute for more money, but a supplement to it in the form of a reward—not a wage. The difference is considerable. The wage is in payment for services rendered, while the emblem award is a recognition for something more than hours of service; it covers loyalty, faithfulness and devotion to duty—things that cannot be purchased with legal tender.

The service emblem and all it stands for is within the reach of all employees and it's simply a pity that more executives do not set it up as a thing worth while working for, since it costs nothing but may mean much to those who merit it.

Plant Service Is as Strong as Its Weakest Link

IN A paper presented before the annual convention of the Association of Iron and Steel Electrical Engineers, J. F. Kelly gives the following relation between production and maintenance in the iron and steel industry:

> The steel industry today is as strong or as weak as its maintenance departments and, argue as you will, its success or failure in any plant is largely due to the manner in which its maintenance departments are organized and equipped. What matters it if your plant can boast of the most modern installations unless you have provided the necessary tools for its upkeep? In a very short time your plant will be subject to annoying costly delays, which interfere with your production schedules, and consequently you are not making profits—but producing at a loss.
>
> You say these are self-evident facts, but in making up budgets for your board of directors, how often is it the case when the estimates are pruned, that the maintenance departments receive the least consideration, and sometimes no consideration at all? There have been instances in the history of the steel industry where fabulous sums were ex-

pended for buildings, mill equipment, power houses; and yet practically no money set aside, worth mentioning, for maintenance departments, with the result that these modern plants were continually being delayed, first by minor breakdowns—then major ones; production was seriously handicapped, all due to the fact that no provisions had been made for maintenance. Here are glaring examples of too much mill—too little shop.

Maintenance, the steel industry will always have with it, and this fact must be fully recognized by the managements, if they desire their production schedules maintained. Maintenance departments are responsible for the continuity of operation, for the development of apparatus which will produce the large tonnages desired, yet too often is this most salient fact overlooked.

Accepting this as a basis for argument, why is it that so little effort and so little importance are attached to seeing that these departments are equipped with all of the modern improvements, calculated to preserve the continuity of operation?

On every hand we hear, first, "Increase your production"; second, "Lower your costs"; third, "Reduce your stores supply." The answer to this it would seem is:

> Organize your maintenance departments and equip them with the same careful analysis you devote to your production problems; if your mills are always prepared to operate, it naturally follows your production will not suffer.

What holds true in the steel mills holds true for all industry. Organize your maintenance department, not with the thought that it is so much overhead which must be kept at a low figure, but with the idea that it is a producing department, producing continuous operation, economical performance, and development of ideas or apparatus for larger production.

Be Sure The New Man Understands His Job

EVERY now and then a new, although supposedly experienced, man will make a mistake or an error in judgment that is difficult to understand. He has claimed to be experienced along certain lines and has proved it by references from former employers, or otherwise. In the face of all this something goes wrong and the cause is eventually traced back to the recently employed man.

Perhaps he is inexcusably at fault, but before this decision is reached and action taken, oftentimes a summary dismissal, it is advisable for the foreman or someone higher in authority to see if the newcomer was given a fair chance. The fact that a man is experienced does not always mean all that it seems to imply. Methods, policies and conditions vary considerably in different plants, so that when a workman goes from one plant to another he may have a good deal to learn, even though he is engaged in the same general line of work. Naturally he wants to make the best possible impression and sometimes rather than admit that he does not fully understand what is to be done, or how to do it, he uses his own judgment—which may or may not be good. In the latter event the results are disappointing all around.

Foremanship involves a good deal more than merely assigning jobs to the workmen. Almost anyone can do that. The real foreman will always make sure that a workman, particularly a new one, not only understands what is wanted and how it should be done, but is capable of doing it. It is unfair to everyone concerned, and poor policy in general, to turn a new man loose on his job without definite assurance that he understands the work fully and is in every way qualified to do it in the proper manner, without instruction.

It's Everybody's Job to Prevent Accidents

SAFETY from the point of view of the executive was so ably presented by B. F. Affleck, President of Universal Portland Cement Company of Chicago in an address at the thirteenth annual Safety Congress recently held at Louisville, Ky., that we want to quote verbatim a few things he said as follows:

> Notwithstanding the great improvement which has been made since the beginning of the safety movement, there is still a great deal of room for improvement in guards and various devices to keep employees away from danger. But as I see it the particular place where there is most room for improvement is in the training and education of the employee.***
>
> Prevention of accidents is, I need scarcely tell you, a large and difficult proposition. It is one on which much more information and advice can be obtained from the novice than from the expert. In other words, the difficulties are less apparent to the outsider than to the man who is called upon to remove them. Executive officers have a great responsibility with respect to accident prevention. They are responsible for providing the means for education in safety, to teach restraint and consideration for the safety of others, and they must realize that they cannot shift the burden of final responsibility.***
>
> In carrying on accident prevention activities there should, of course, be a comprehensive safety organization consisting of officials, foremen and workmen, because if safety work is to be a success it must be everybody's job to prevent accidents.

Mr. Affleck put his finger on a vital point, we believe, when he said, "It must be everybody's job to prevent accidents." So much attention is so often paid to speeding up production and cutting down its costs that the part played in this work by lost-time accidents is not always given due consideration. Entirely aside from the loss that can be expressed in dollars, resulting from frequent lost-time accidents, there is an even greater loss that is hard to make up in changes in the production organization through fatal injuries to trained men and the fear that quickly grows up in an operating force that certain departments are dangerous and undesirable places in which to work.

To illustrate the importance of these viewpoints, Mr. Affleck quoted from letters by Judge Gary, President of the U. S. Steel Corporation, to presidents of subsidiary companies, in which he said that there would be no hesitation in making the necessary appropriations of money to carry into effect every suggestion that seemed to be practicable for the improvement of conditions in their mills. In this connection he pointed out that much can be done by designing new construction and machinery with all practical safeguards. "Nothing," said Judge Gary, "which will add to the protection of workmen should be neglected, for the safety and welfare of our workmen is of the greatest concern." As a practical illustration that he meant what he said, a total of $126,885,911 was spent for safety and welfare work from January 1, 1912 to January 1, 1923 through the suggestions and co-operation of 84,491 men who have served on safety committees. At the present time 10,331 men in the Steel Corporation are serving on safety committees and from January 1, 1912, have brought about a reduction of better than 70 per cent in all disabling accidents.

This saving in man-power and improvement in conditions under which they work is truly of great concern to American industries and it's the job of every one engaged therein to do a part, from workman to chief executive.

Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

Who Can Answer These?

Lining Up Sprockets for Chain Drives—Can some reader tell me the best and simplest method of lining up sprockets, or shafts, for chain drives? We frequently change machines around and install new drives or replace old ones, and I should like to be sure that we are lining these up properly.
Decatur, Ill. J. L. B.

* * * *

Motor-Generator Set for Testing Small Single-Phase and Three-Phase Motors—Will some reader please tell me what capacity motor-generator set (d.c. motor—a.c. generator), method of drive and style of generator I could use for testing single-phase and three-phase, 60-cycle, 220-volt motors up to 1 hp. rating? Is it possible to change over from 25 cycles to 60 cycles, from 110 to 220 volts and from single phase to three phase, or the reverse, just by means of throwover switches? What changes would have to be made in the motor and generator in order to secure 25-cycle current? What capacity would be obtained from a 60-cycle set delivering 25-cycle current?
Chicago, Ill. E. J.

* * * *

Commutator Trouble with Interpole Motor—I have a 15-kw., six-pole, compound-wound, interpole exciter, for a synchronous motor, that has three black and somewhat flat spots at equal intervals around the commutator. This machine has a lap winding and the mica is not undercut. There is always some sparking at the brushes. If I shift the brushes, the black spots move in the direction the brushes are shifted. I lifted the leads from their risers at each spot and tested for open circuits with a test lamp, but everything seemed to be O. K. Will some reader please suggest a cause and the remedy for this trouble?
St. Croix Falls, Wis. K. A.

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Operating 25-Cycle Transformers on a 60-Cycle Circuit—We are operating a 2,300-volt, sixty-cycle, three-phase system and in a short time will be called upon to furnish some additional lighting and power service. Our present transformers are not sufficiently large to handle this additional load and we do not wish to purchase new ones as the load will be on for only a few days. We can rent 2,300-volt, twenty-five-cycle transformers and I should like to know if these will work satisfactorily on the sixty-cycle current. Will the secondary voltage be the same as on twenty-five cycles? If not how much will it be below normal?
Carthage, Mo. A. P. K.

* * * *

Why Can Not This Motor Be Speeded Up?—We have a Westinghouse, type SK, 7½-hp., 1,150-r.p.m., 110-volt motor that is giving us trouble. The nameplate says "Shunt Wound, Continuous Speed," but it has a series field, shunt field and interpoles. For several years this motor ran satisfactorily, until a brush was replaced. The new brush was identical with the old one.

The motor picks up regularly and carries the load, but as soon as the field is weakened to increase the speed the load fluctuates badly; the more the field is weakened the more the load swings until there is a sharp flash at the brushes or a fuse blows. All kinds of connections have been tried, without results. The speed of the motor when running the machine is from 1,150 to 1,500 r.p.m. When the trouble started the machine was running at 1,800 r.p.m. The same trouble occurs with all of the different motors of the same type that we have tried on this machine, although it can be driven satisfactorily by a straight shunt motor of less horsepower rating. Can some reader tell me the cause of this trouble?
Norwood, Mass. E. F.

* * * *

Starting Trouble with Motor-Generator Set—In starting a synchronous motor-generator set the motor field is first short-circuited by the double-pole, double-throw, quick-break switch, which is provided with a short-circuiting resistance contact that closes just before the switch is opened from one direction and opens just before the switch is closed in the other position. The motor is started and comes up to speed on 2,000 volts; the field switch is then thrown to obtain excitation from the 250-volt bus. The running voltage of 6,600 volts is then applied. When the field switch is thrown from starting to running positions there is a bad flash between the hinge clips and the short-circuiting resistance jaw. What is the cause of this flash and how may it be avoided?
Pittsburgh, D. W. B.

Answers Received To Questions Asked

Trouble Caused by Plugging Elevator Motor—Will some reader of INDUSTRIAL ENGINEER please give me some help on the following problems? (1) We have a 10-hp., 550-volt, three-phase elevator motor which is controlled by a Cutler-Hammer reversing switch. We are experiencing a good deal of trouble from blowing of fuses due to reversing the motor before the elevator comes to a full stop. This elevator has no regular operator and is used for freight service only. Has anyone had similar trouble and what is the best method of overcoming it? (2) Is it possible to wind a magnet that will lift from 10 to 25 lb. and can be operated on a 110-volt, sixty-cycle circuit? If so, please give me the winding data for 110 volts and also 550 volts.
Millbury, Mass. L. A. T.

Referring to the question by L. A. T. in the October issue, I would say that the trouble is probably the result of poor adjustment of the brake on the elevator machine. It would be advisable, at any rate, to inspect the brake mechanism on this machine and see that it stops the machine promptly and without too much sliding. Without more detailed data as to the scheme of connections it is hardly possible to advise L.A.T. much more on this point.

In reference to his second question, I would say that it is quite possible, and not at all difficult to wind a magnet for operation on 110 volts a.c., to lift 10 to 25 lbs. But before determining the winding data, it is necessary to know the dimensions of the magnetic circuit and the space available for the winding.
Honesdale, Pa. J. M. WALSH.

* * * *

Referring to L. A. T.'s questions in the October issue of INDUSTRIAL ENGINEER it appears that a drum-type, rope-operated, reverse switch is being used with apparently no main switch. There are several types of reverse switches manufactured, and from what is said it would appear that there is no main switch to break the circuit at the time the drum is moved in the neutral or central position. It is very possible that the centering device has shifted on the drum shaft so that when stopping it breaks the circuit in one direction and moves through the neutral into the reverse, plugging the motor; then further action on the drum returns it to the off or neutral position. I suggest checking up the travel of the rope-operated sheave wheel and centering device with respect to its position in the drum. If a main switch were connected the opening of the circuit in the drum would drop out the main contactor and prevent an inrush of current in case the centering device throws the segments of the drum to the extreme reverse position. It might also be that the motor is not properly fused, and I suggest that this be checked to see if 30 amp. fuses are being used. It is also suggested that the solenoid or motor-operated brake be checked to see that it is functioning properly at the time of stopping.

I trust that the above information will be of some help to L. A. T., and if he desires further detailed information suggest that he write directly to the Cutler-Hammer Mfg. Company giving the serial number of the control equipment and explaining the difficulty he is having.

If the second question refers to a lifting magnet, the answer is No; but if the question pertains to a solenoid magnet used to lift a given amount attached to a lever or valve, the coil can be wound for both 550 volts and 110 volts, alternating current. No mention is made as to whether it is to be used for continuous or intermittent duty, and since the coil data depends upon the design of the frame, it is difficult and would be practically useless to give any coil-winding data. To make up an a. c. solenoid magnet, laminations are required which are riveted together under hydraulic pressure and fitted to a steel frame. Such work rquires apparatus usually not available in the average shop, and we believe that such magnets can be purchased at a fair price and much cheaper than they could be made.

I shall be glad to give L. A. T. any information that I can, regarding the types and sizes of magnets now on the market, if he will write to me or to the Editors of INDUSTRIAL ENGINEER.

E. H. LAABS.
Engineer, Printing Equipment Dept.,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

* * * *

Why Do These Commutators Turn Black? —I am experiencing a great deal of trouble from blackening of the commutators on two G. E. belt-driven, type ML, compound-wound, 125-volt, 950-r.p.m., 13 kw., d.c. generators which are used as exciters. After smoothing with sand paper, it is only a matter of a few hours until the commutators are in the same condition again. I have tried turning the commutators in a lathe and undercutting the mica, polishing, sanding, using Ideal commutator stone and tightening the commutator. Also, I have used four different grades of brushes and am now using Speer E-25 brushes. There is no sparking at all under varying loads. The setting of the brush holders was changed from leading to trailing and I found that they worked best leading. I have tried the brushes at different angles and found that the best results were obtained when they were set at about 80 deg.

We wipe off the commutators once each day with a dry piece of canvas. I have checked the brushes for the neutral position. The tension on the brushes is 1½ lb. per sq. in. The temperature seems normal except when the commutators get very black as they will do if they go about a week without sanding. These exciters are only two years old and have been in actual service about one year each. I have had this trouble from the start.

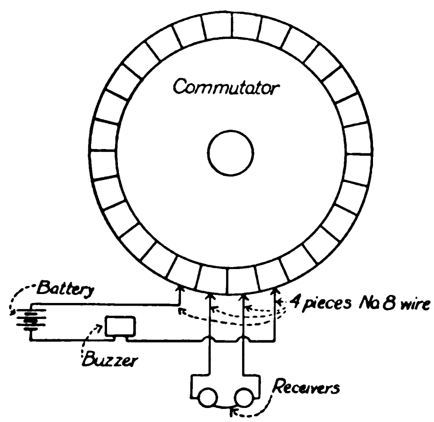
I shall appreciate it very much if some reader of INDUSTRIAL ENGINEER can tell me what the trouble is and how I may cure it.
Woodward, Okla. H. J. A.

In reply to the question by H. J. A., in the August issue of INDUSTRIAL ENGINEER, from the information given it is quite evident that the trouble cannot be diagnosed very easily. Not being as familiar with this trouble as the people in the immediate vicinity I would not attempt to say what the trouble is except that it is probably inherent in the design or some difficulty either in the casting or a variation in the materials used in the generators, making these machines somewhat different from the average run of the particular type of generator in question. This is not unusual, as we frequently encounter such conditions.

However, as to the cure, we have cured such cases in the past by the use of a high-contact resistance brush with an abrasive action. The high contact resistance tends to reduce the blackening by limiting the current more nearly to the load current, and cutting down the cross-bar currents. The abrasiveness of the brush takes the place of the sand paper which is used once a week. I believe that this condition can be cured by the use of the proper brushes and I would be glad to co-operate with H. J. A. from this standpoint.
Pure Carbon Co.,
Wellsville, N. Y. R. J. COLEBERT.

* * * *

Answering H. J. A.'s question in the August issue, in most cases blackening of commutators is caused by excessive sparking at the brushes, or by too much lubricant. Sparking does not seem to be the cause of the trouble in this case, however, for H. J. A. states that his machines do not spark at the brushes. I would suggest, however, that he test his armatures to find out if there are any defects in them. This can be done by means of a pair of wireless telephone receivers, two dry cells and a buzzer, connected as shown in the diagram. I have found that four pieces of No. 8 wire about 8 in. long, bent



Method of testing commutators for open circuits and other defects by means of a buzzer and telephone receivers.

over slightly on the end, insulated from each other with tape and then taped together so that each will touch a segment in the middle, make convenient testing leads. When testing with this outfit start at a marked segment and test each segment around the commutator. If the coil or segment under test is normal, there will be a clear buzz in the receivers. In case there is a poor connection or open circuit there will be a buzz in the receivers about twice as loud as is obtained normally. With a short circuit there will be no sound.

When testing for a ground, place one of the buzzer leads on the frame of the machine under test and connect the other lead to the commutator; also connect one of the telephone receiver leads to the machine frame and with the other lead touch each segment until one is found that gives no sound in the receivers. The one that gives no sound is the grounded coil or segment.

I would also advise checking the position of the brushes. This will require the use of a low-reading volt meter, say five or six volts. Take a dry, wooden block, cut it into the shape of a brush and through it drill two small holes that will reach the center of two adjoining commutator bars. Place in these holes two pieces of lead out of a pencil, and to these pieces connect the voltmeter leads. Take out one of the regular brushes and put the wooden brush in its place. Then run the generator under light load but at full speed and rated voltage and shift the brushes backward and forward until the point is found where the voltmeter gives the minimum reading. This is the neutral point and the machine should work well when the brushes are set on this point.

I would also suggest that the commutator segments be counted and the brushes spaced so that they have the same number of segments between them.

The use of commutator lubricant is bad policy after commutators have been undercut, as it causes carbon and dust to collect between the segments. Oil will sometimes come from the shaft and gather on the commutator and produce similar troubles. Washing the commutator with benzine and letting it dry thoroughly is about the only remedy for this condition.

As to grinding commutators, I do not consider this good practice to follow very frequently, as it is very difficult to hold any form of grinding stone so as to cut the commutators true and they soon get out of round which, in turn, is another cause of commutator trouble.
Galesburg, Ill. EARL BABER.

* * * *

Referring to the commutation troubles reported by H. J. A., in the August issue, in connection with two ML compound-wound exciters rated at 112 amp., 125 volts, 950 r.p.m., I would like to suggest that he try operating these at 125 volts instead of 95 volts as reported. It would also be advisable to check the speed and make sure that the exciters are not operating at more than 950 r.p.m.

The design of these particular exciters is such that the best results will be obtained when they are operating at rated voltage and rated speed. If either the voltage is low or the speed is high, trouble may be experienced.

C. M. FULK.
Central Station Engineering Dep't.,
General Electric Co.,
Schenectady, N. Y.

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Advantages of Star- and Delta-Connected Motor Windings—I wish someone would kindly give me some information on the following questions. Why are some three-phase motors star-connected, and some delta-connected? What are the advantages of a star-connected motor over one that is delta-connected? I shall appreciate it very much if someone will explain this to me.
Toledo, Ohio. F. H.

Referring to the question by F. H. in the September issue of INDUSTRIAL ENGINEER, I believe there is no way to predict the form of the stator windings of an induction motor. Whether it is star or delta connected depends entirely on the designer who first lays out the machine. A motor of a certain horsepower, speed, and voltage requires a certain flux or magnetic density. This flux density can be obtained by varying the pole pitch, number of conductors,

and by using a star or delta connection. Sometimes the best combination is obtained by a star connection, and sometimes by a delta connection. The number of slots in a certain size motor may give the best results by using a star connection and a certain number of coils. Another rating may lend itself best to the delta connection. Of course, if a certain rating, say 20 hp. 1,200 r.p.m., 60 cycles, 220 volts, by a certain manufacturer, is found to be delta connected it is pretty safe to predict that all other motors of this rating by this manufacturer are also delta connected. However, a duplicate rating by another manufacturer might be star connected, because another designer may have decided to use a different combination of slots, coils and winding.

Schenectady, N. Y. ROGER F. EMERSON.

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In reply to the question by F. H. in the September issue, if we take two motors, one star- and the other delta-connected, of the same size, same horsepower and wound for the same voltage, we will find that the efficiency will be the same; or we can take the motors and change the type of winding on them and still get the same results. Thus, it would appear that one winding is as good as the other. But on examination we will find that the star winding has fewer turns of a larger-size wire than the delta winding has; in other words the delta winding will have a greater number of turns of smaller-size wire.

Now if we take a delta-connected motor wound for 100 volts and reconnect it star, we will have a motor suitable for 173 volts, which means that the star connection will stand 1.73 times as much voltage as the delta connection. Then for high voltages the star connection is superior to the delta, inasmuch as there are fewer turns of wire in the coils and less slot insulation is required.

Muncie, Ind. GEORGE CROPPER.

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In answer to F. H.'s question in the September issue, I would say that a motor has to be designed to operate either star or delta connected. That is, the connection cannot be changed haphazardly.

The real advantage of a star connection over a delta connection is found in high-voltage machines. In a motor the slots are small and it is difficult to insulate the coils from the stator. In any case the more copper there is in a slot, the better. Therefore, with a star connection, the voltage per coil is only 58 per cent of the line voltage. If a motor is rated at 2,300 volts the voltage per coil will be only $2,300 \div 1.73 = 1,330$ volts, for which the coil will have to be insulated. In a delta connection the voltage per coil is the same as the line voltage and in this instance the coils have to be insulated for 2,300 volts. Therefore, the coils in a delta-connected motor have to be more thoroughly insulated than in a star-connected motor.

Labor and insulation are expensive; so any reduction which can be made in either, represents a saving.

Revere, Mass. PAUL FEENEY.

How Should This Machine Be Placed?—It is common practice to place a pulley at right angles to a lineshaft which, of course, means that the belt has no twist in it. However, we have a 125-ton press and would like to place it in such a position that the pulley on this press will be 45 deg. from the lineshaft. I should like to know, (1) if this is an unusual way of running a belt, and (2) how should the machine be placed with the pulley in this position, so that the belt will not be continually slipping off.

Philadelphia, Pa. A. T. S.

Replying to A. T. S. in the August issue, (A) in the illustration shows the relative location of the shafts, pulleys and belt. Also, (SP) represents the lineshaft pulley and (MP) the machine pulley, the center lines of whose axes lie in different horizontal planes, but at an angle (x) instead of being parallel, as is usually the case. It is possible, and practicable, to install pulleys for any value of (x) between zero and 180 deg., provided the shaft centers are sufficiently separated.

For successful operation it is essential that plane (MM') of the lineshaft pulley and plane (NN') of the machine or driven pulley intersect so that points (b) and (c) will lie in both planes. Point (b) is the point of tangency between the belt and the machine pulley where the belt leaves the pulley. Point (c) is the corresponding point of tangency on the lineshaft pulley.

Relative location of shafts, pulleys and belt when the axes of the shafts lie in different horizontal planes and at an angle to each other.

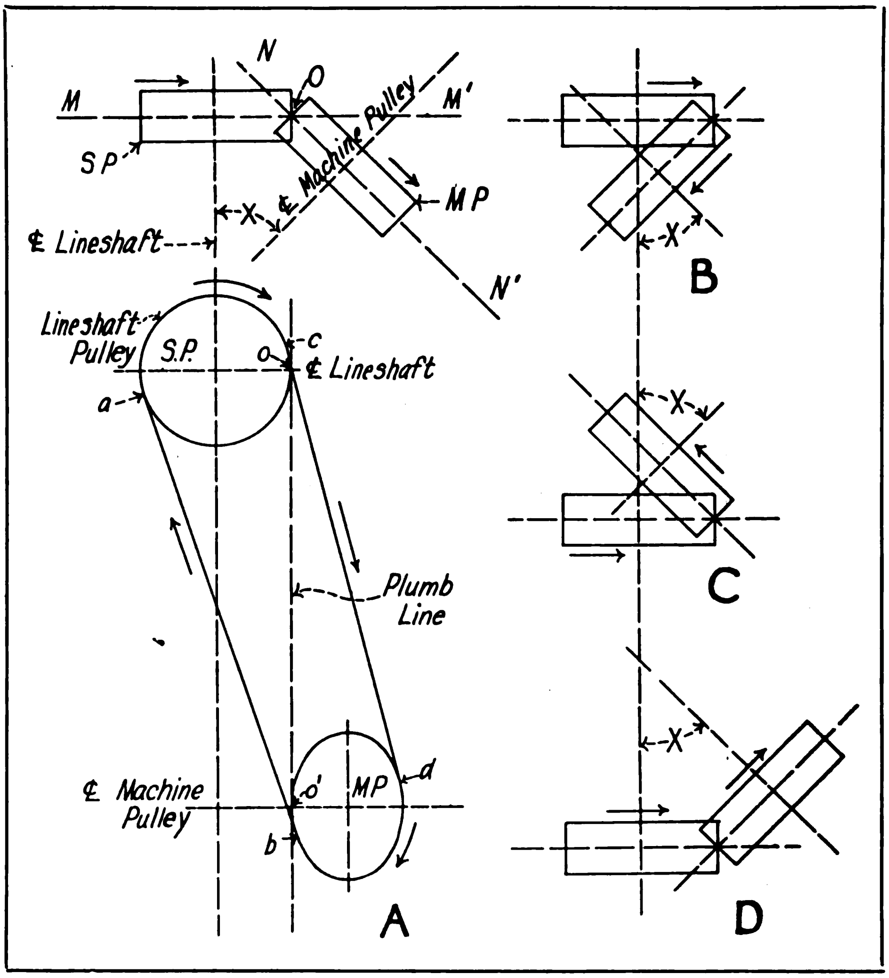
It can be stated, in general, that the point on a pulley where a belt leaves it must be so located that the belt will be delivered to the center of the face of the receiving pulley. If this condition is rigidly adhered to there will be no difficulty in installing pulleys at any angle, provided the centers are sufficiently spaced and the shafts do not lie in the same plane. From this it is evident that in a given installation the direction of rotation of the pulleys is not reversible.

If the pulleys are both very nearly the same size the approximate location can be determined by dropping a plumb line from point (o) on the lineshaft pulley and placing the machine pulley tangent to the plumb line. In order to get the exact location it may be necessary to move the machine a little to compensate for the slight differences in position of points (o) and (c) and (o') and (b) on the pulleys.

For each angle (x) there are four possible positions in which the machine or driven pulley may be placed relative to the lineshaft pulley. In two of these positions the machine pulley will be driven in one direction and be reversed in the other two positions. In the illustration (B), (C) and (D) show the three positions and direction of rotation not shown in (A).

It should be noted that the point at which the belt leaves the pulley is a controlling feature in installations of this sort. If attention is paid to this no trouble should be encountered in the solution of the problem.

Wilmington, N. C. CHAS. R. SUGG.



How Does Change in Speed of Motor Affect Horsepower?—I shall appreciate it if some reader of INDUSTRIAL ENGINEER can answer the following question: We have a 3-hp., 3,600-r.p.m. motor which we are changing to operate at 1,800 r.p.m. I should like to know what the approximate horsepower of the motor will be after this change, if we use the same number of turns of the same size wire in the stator.
Enid, Okla. C. E. S.

In reply to the inquiry by C. E. S. in the August issue, he does not state whether this is a d.c. or an a.c. motor. Assuming that it is an a.c. machine, changing it from 3,600 to 1,800 r.p.m. using the same size of wire and the same number of turns in the stator as before, would not be very satisfactory. When changing the speed of motors remember that the counter e.m.f. is higher at high speeds than at low speeds and the turns are, therefore, less for high speeds.

In rewinding this motor for 1,800 r.p.m. wind it for four poles, with twice the number of turns and half the size of the wire in the present winding. The horsepower will be approximately 1½.
Los Angeles, Calif. H. A. NIELSEN.

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In reply to C. E. S. in the August issue, the horsepower will decrease in direct proportion to the decrease in speed, assuming that you use the same size of wire. In your case the new horsepower will be $1{,}800 \times 3 \div 3{,}600 = 1.5$ hp., but if you change from two poles to four poles to get 1,800 r.p.m., you will have to change the connections of the motor. If it is now two-circuit star or delta, you will have to change it to single-circuit star or delta, as on half speed, 1,800 r.p.m., it will only produce one-half of the counter-electromotive force that it would on 3,600 r.p.m.

The chord factor must also be considered. Say your motor has thirty-six slots; then full pitch would be $36 \div 2 = 18$, or slots (1) and (19), and the chord factor would equal 1. Now on four poles, it would be $36 \div 4 = 9$ or slots (1) and (10). The motor would then be over-pitch which has the same effect as under-pitch. The four-pole chord factor would be only .707 which would cause the motor to run hot. Therefore, it would be advisable to rewind the motor with the proper chord factor and use twice the present number of turns with half the wire size. Use the same chord factor, from full pitch, that the two-pole winding now has and connect the motor for the same number of circuits that it had before, assuming that you desire to use the same voltage as before. Of course, you can, if you have room in the slots, use larger wire and thereby increase your horsepower. If you use a little less insulation and single-cotton-covered wire, you should be able to get a larger wire in the slot.
NICHOLAS J. WEISS.
West New York, N. J.

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In answer to C. E. S.'s question in the August issue, I am taking it for granted that this is a polyphase motor. Then, hp. = (torque × r.p.m.) ÷ 5252.

The motor as originally wound developed 3 hp. at 3,600 r.p.m. It will, therefore, develop 1½ hp., when reconnected for 1,800 r.p.m., because the torque has not been changed and the speed has been reduced one-half. The torque cannot be changed very materially for the core is so designed that the motor will produce its full torque when the magnetic density is nearly at the limit.

A change in speed must be accompanied by a change in the applied voltage. Assume, for example, that this 3-hp. 3,600-r.p.m., three-phase motor has thirty-six coils, two poles and is connected series star. When it is changed to four poles, 1,800 r.p.m., we still have thirty-six coils and the same number of turns per coil with a series-star connection, but the rotating magnetic field is only making 1,800 r.p.m. instead of 3,600 r.p.m. Then the counter-electromotive force will be reduced one-half. This would allow approximately twice the normal current to flow through the stator winding, which would soon be burned out.

If the motor were connected double star, it could be reconnected series star for operation at 1,800 r.p.m., and would give fair results on the original voltage. Or the original connection could be used and the motor operated on one-half the original voltage. Of course, other connections could be used, but I have cited these merely as examples.
Galesburg, Ill. EARL BABER.

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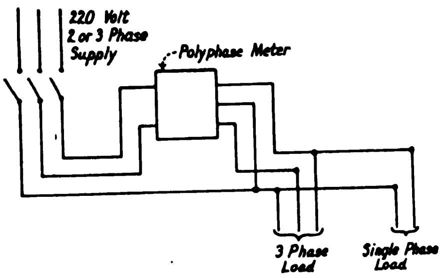
Single-Phase Load on Polyphase Meter—Will some reader of INDUSTRIAL ENGINEER please tell me what will be the difference, if any, in the real power consumption as compared with the meter reading when a single-phase load and a polyphase load are taken from one polyphase meter, as shown in the diagram. The polyphase load seems to



be registered correctly, but will the meter register too much when single-phase power is used? If so, would the same result be obtained on both two-phase and three-phase circuits?
Northampton, Mass. L. G. D.

In answer to L. G. D. in the August issue, when a single-phase load is connected to a polyphase meter, there should be no difference between the power consumed and the amount recorded on the meter, provided, of course, that the meter is accurate and is connected properly. Connecting a single-phase load on a polyphase system, either two or three phase, results in an unbalanced system and all polyphase meters should record the true power consumed, regardless of whether the system is balanced or unbalanced.

Sometimes, however, polyphase meters are found to run a little fast or a little slow when operating on an unbalanced polyphase system, even though the connections are correct. Usually this is because the torques on the meter elements are unequal. The meter should be adjusted so that when the same amount of power is passed through each element, the torque on each is equal. If this is not done, when the meter is operating on an unbalanced system it will run too fast when one element has more of the load passing through it, and will run too slowly when the other element is carrying the heavier load. ERNEST DICKINSON.
Kimberley, B. C., Can.

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In answer to L. G. D.'s question in the August issue, a polyphase watt-hour meter which is connected correctly to measure two-phase or three-phase power will indicate the power consumed on the "load" side of the meter regardless of the condition of balance. Since the case presented is simply a two-or three-phase load which is unbalanced, due to the addition of the single-phase load to one phase, the meter will, if properly connected, correctly indicate the watt-hours consumed.
Toronto, Can. HERBERT KING.

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In the August issue of INDUSTRIAL ENGINEER, L. G. D. asked about the accuracy of metering when a single-phase load is connected to a polyphase meter.

In its present form his question is far from being clear, as he does not show the inside connections of the meter. However, I presume that this is the usual type of polyphase meter, which is essentially a combination of two single-phase meters. Such a meter is able to measure accurately a polyphase load even if the phases are unbalanced. The readings of the instrument will, therefore, be correct regardless of whether the single-phase load is taken alone or at the same time as the three-phase load. P. VAN HERK.
Liege, Belgium.

* * * *

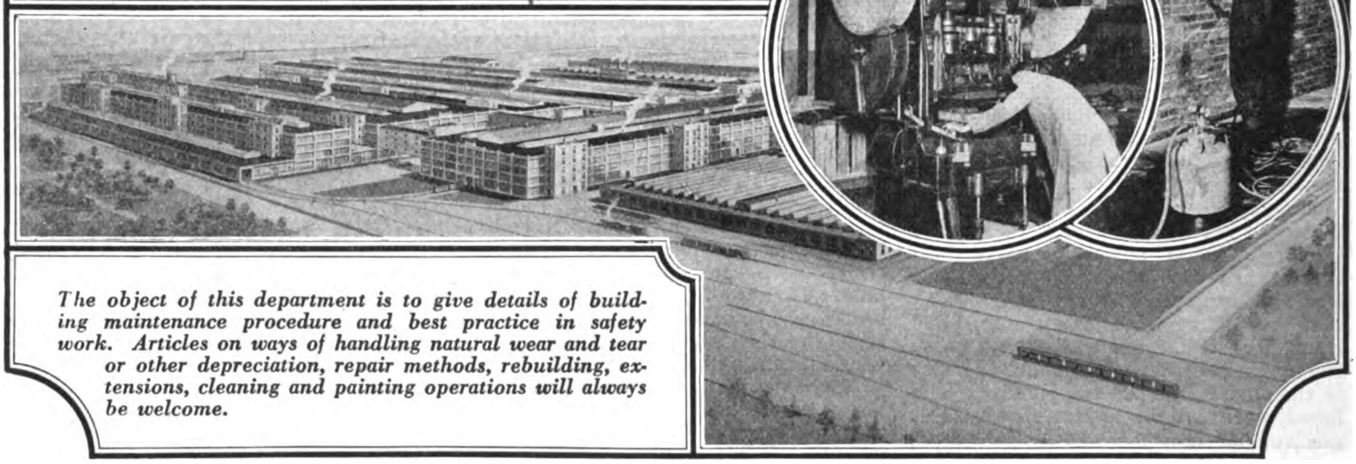
Answering L. G. D.'s question in the August issue, there is no theoretical reason why this meter should not give an accurate record of the consumption of single-phase power, if it has been properly adjusted. A three-phase load rarely has a 100 per cent power factor and the torque on the two elements, therefore, is not the same; in other words, if two single-phase meters were installed in place of the polyphase meter they would not read alike unless the power factor were 100 per cent. In fact, at 50 per cent power factor one of the meters would read zero.

In any watt-hour meter an adjustment must be made for light loads and unless this is done the record of consumption at a low speed may be very much in error in one element.

The registration of a polyphase meter is dependent on the sum of the torques of the two elements and the addition of a single-phase load will, therefore, only add to the torque of the polyphase load in its proper phase relation and a correct reading will be obtained.

Should there be any doubt as to the accuracy of the polyphase meter it should be checked against two single-phase meters rather than against another polyphase meter, since the former would indicate with more certainty where the discrepancy, if any, exists.
C. OTTO VON DANNENBERG.
The J. G. White Engineering Corp.,
New York, N. Y.

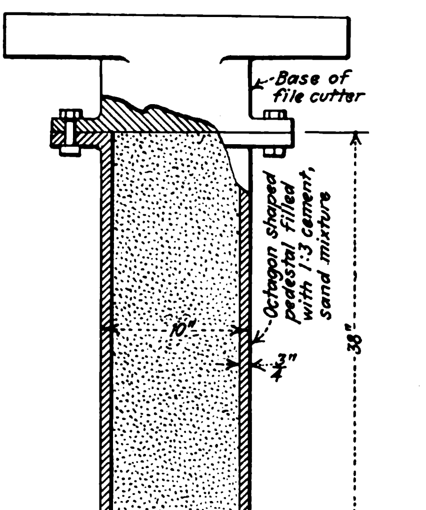
Building Maintenance and Plant Safety



The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Concrete in Machine Pedestals Absorbs Hammer Shock

PRACTICALLY all file teeth are cut in special machines of the punch-press family with an open side in which a hammer weighing from 1 lb. to 100 lb. falls from 200 to 1,000 times a minute. The lower end of this hammer carries the chisel which cuts the annealed blank while the blank is fed along at a rate which produces coarse or fine teeth. In addition to the weight of the hammer itself, the power of a spring is put behind the hammer to make the right kind of a cut in the steel blank. Such pounding as this, all day long, demands a rigid machine and a husky foundation. It is customary to place a cast-iron pedestal between them and fastened to each. The general practice is to carry the throb of the file cutter down to a foundation in the ground.



Filling this pedestal between the machine bed and the foundation with a 1-to-3 cement-sand mixture insures, at low cost, greater rigidity of the machine.

The accompanying drawing shows a method now employed to secure mass and rigidity in the pedestals under such machines at a relatively low cost. The pedestals are filled with concrete after they are placed and bolted down.

As will be noted, the under side of the machine bed rests directly on the concrete inside the pedestal. This is purposely done to make it take its share of the load. On those machines that were made with a recessed center, a flat iron plate has been placed between base and pedestal to distribute this load over the entire surface.

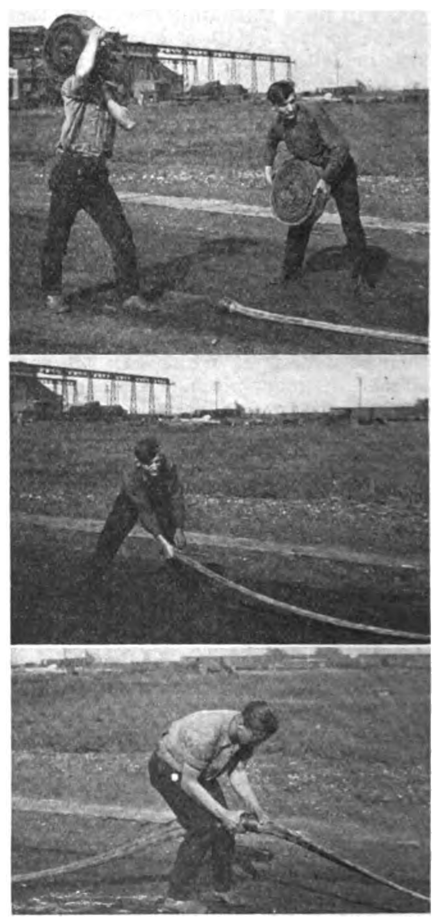
A 3-to-1 mixture is used inside the castings without stone or cinders in it. The slight additional cost of using the richer mixture is fully justified. When it is desired to go further toward making a good job, the pedestals may be faced on the bottom and rested on a metal plate set in the foundations. Then although the pedestal practically rests on a machined surface a little thin cement is poured into the pedestal at first.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.

Methods of Handling Fire Hose When Connecting Up

IN ORDER that the members of the fire department and other employees who are engaged in volunteer fire protection, may understand better the methods of handling a hose, The Pullman Company, Chicago, Ill., published in its shop paper, the accompanying illustrations showing how a hose should be handled. The upper illustration, for example, shows the two positions taken for unrolling a hose. The man on the right is using an underhand roll as in bowling, while the other is taking the position for what is known as the shoulder roll. The second illustration shows the completion of the roll. As the hose unrolls, the operator gives it a jerk to straighten out the 50-ft. length.

The third illustration shows the proper position for making a coupling.



Three steps in coupling a hose.

To show their employees how to handle fire hose, the Pullman Company have printed in their shop paper these three photographs which show how to unroll the hose, how to straighten it, and how to couple it.

The "female" end of the coupling is held between the knees and the "male" end is held by the left hand with the right hand in position to turn up the coupling. Care must always be exercised so that the threads are not jammed nor the coupling started incorrectly, as in any case time is a very important element. Also, damaged threads may hold up getting the stream on the fire until it has made a good start.

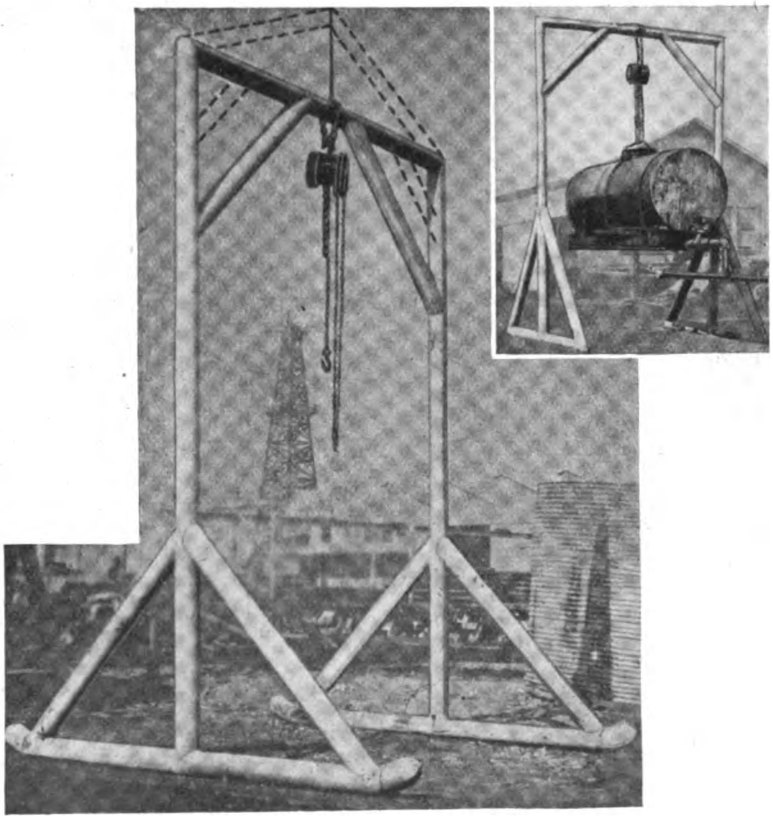
Portable Derrick for Handling Miscellaneous Loads in Plant Yards

STORAGE yards usually contain a miscellaneous assortment of heavy materials which are difficult to load or unload by hand. Even though a large derrick may be located in the yard, it is not always available because it may not be within reach. As a result, wood "A" frames and various miscellaneous makeshift derricks are commonly used. While these serve the purpose, they are generally more or less unwieldy and are hard to move about and erect, as they often require guy ropes.

One oil company has devised an ingenious substitute for these makeshifts in the form of a derrick, shown in the accompanying illustration, which is fabricated entirely from pipe by oxy-acetylene welding, as recently explained in "Oxy-Acetylene Tips" issued by The Linde Air Products Co. The feet are bent up at the end to serve as skids on which the derrick is readily dragged from one location to another. The derrick is wide enough to straddle the object to be lifted whether it is on a motor truck or on the ground. The load is then hoisted by means of a chain block and the truck driven under or backed out and the load deposited on the ground. Loads that are not too heavy may be handled a short distance by lifting them and then dragging the loaded derrick to its new destination.

Actual fabrication of such a derrick may be left to a good welder but the design should be made by a trained engineer. For instance, while the derrick illustrated is probably capable of supporting any load within the range of the ordinary chain block, it could sustain a load several times as great if the top members were arranged in the form of a king post truss as shown by the dotted lines in the illustration at the left. In such a case the angular braces just under the cross bar could be shortened.

This portable derrick for supporting a chain block when handling yard material was made by an oxy-acetylene welder from scrap pipe.



Effect of Annealing Hoisting Sling Chains

IN a paper on the safe operation and use of hoisting chains, presented at the recent Safety Congress held at Louisville, Ky., A. V. de Forest, an engineer with the American Chain Company, Bridgeport, Conn., gave some interesting results that may be expected through annealing chains when an elongation indicates that they have been overloaded. Wear is sometimes a factor in causing elongation of a chain and it is necessary to distinguish between this effect and that of overload.

Regarding annealing when a chain does not show signs of wear, and why it tends to lower the working load but increases the factor of safety under shock, Mr. de Forest had the following to say:

"It is well known that annealing restores its original properties to cold-worked or distorted metal. At the same time it destroys the increased strength due to that cold work. As far as mitigating the effect of fatigue is concerned, it naturally can have no healing effect upon a failure already started, but it can and does lower the resistance to deformation.

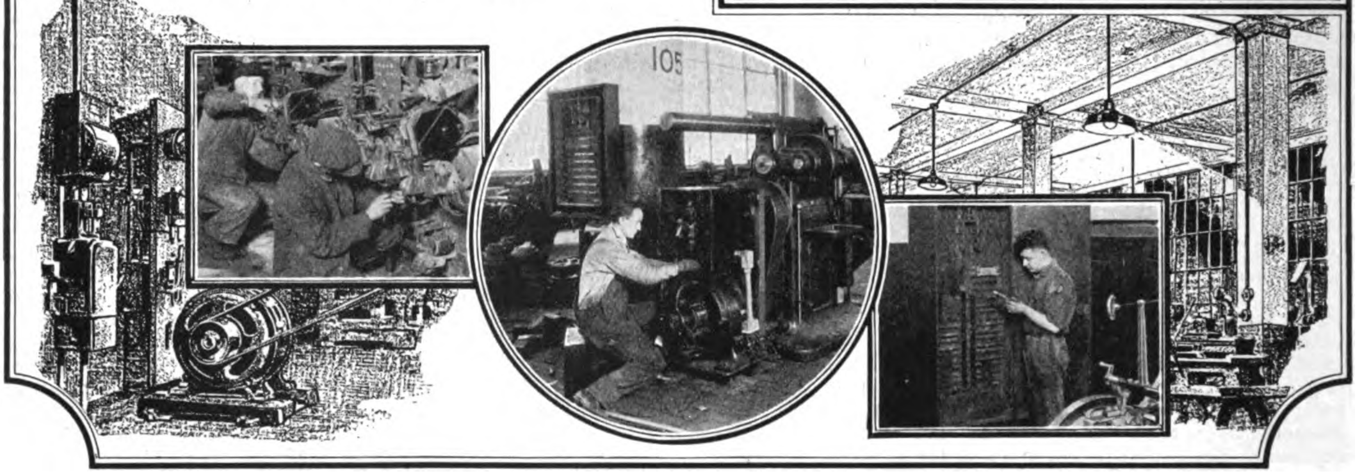
"To illustrate: A 1-in. chain normally breaks at 60,000 lb. with 15 per cent elongation. A proof stress of 30,000 lb. will cause more elongation, but without careful measurement by inspectors the load could rise to 35,000 lb. with perhaps 6 per cent elongation. Repeated loads just below this figure would start fatigue cracks and final rupture without appreciable further elongation. If, after the first application of the 35,000-lb. load the chain had been annealed, it would start stretching at about 28,000 lb. and again would show nearly 15 per cent elongation, and if the 35,000 lb. were once more applied, the elongation would be so great that overloading would be self-evident. Here the annealing would act to protect the chain from further abuse. Suppose, however, that the loads repeatedly applied were 30,000 lb. and the chain were not annealed after its one application of the 35,000-lb. load. It would carry these loads without danger, but would have lost the 6 per cent elongation taken out by the 35,000-lb. load and the resulting greater shock-resisting power. Briefly, the annealed chain has greater resistance to breaking under a single shock load; the unannealed chain can stand a higher repeated load, and has a higher working strength, but does not have as great a resistance to a single shock.

"The greatest benefit from annealing lies in the fact that it automatically increases the factor of safety. If improperly carried out, that is, if the chain is heated too hot, kept hot too long, or cooled too slowly, it weakens the chain. In general, it is only useful after the chain has been distorted by an overload and to lower the working load. It should not be done periodically as a "cure all," but, carried out in conjunction with careful inspection, it will add to the safety of lifting and hoisting operations.

"Annealing, however, can only restore ductility in the metal and does not affect the loss in elongation due to permanent deformation of the links. No chain should be used on important work after it has been badly overloaded and has thereby lost a considerable proportion of its remaining elongation. Its tensile strength may be unimpaired but its reserve of shock strength is gone. If annealing is carried out, the chain should be heated to a uniform temperature of between 1500° F. to 1600° F., kept at heat only long enough to reach this temperature throughout and cooled freely in air."

Electrical Service
Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Accessibility Is Important Factor in Maintenance of Lighting Units

THE usefulness of a reflector is easily and rapidly lost through the accumulation of dirt—and the measure of the value of the reflector is in the ability of its reflecting properties to bend the rays of light back and deliver them, without loss of intensity, between useful angles in the working area.

Obviously it is as necesary to restore these reflecting properties whenever they become impaired by dirt as it is to refill a gasoline tank when it becomes empty. It would be as absurd to build an automobile without making provision for refilling the tank as to install a reflector without making adequate provision for cleaning; nobody has ever found any kind of dirt that will save light.

And just because nobody thought to make provision for keeping them clean thousands of high-grade reflectors, all over the country, are now rotting away with dirt and rust, without performing the work for which they were purchased. It is dirt that destroys a reflector—for it is dirt that collects corrosive elements—and it is dirt that prevents the reflector from performing its proper function.

The greatest problem in lamp maintenance is accessibility, but this work can now be done easily and economically by installing the lamps on a safety lowering switch, or disconnecting hanger, enabling them to be lowered away from the electric circuit for the cleaning of reflectors and renewal of bulbs, thus eliminating climbing hazards and also eliminating all electrical hazards, by keeping the man entirely out of reach of the electric circuit.

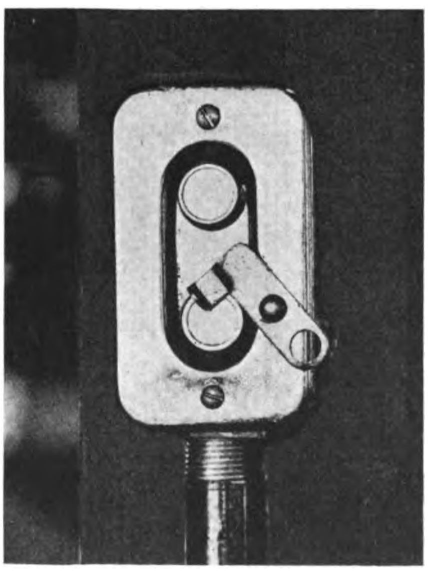
A perfectly clean bulb may be put into a dirty reflector without accomplishing anything, or at least not much; but it is a certainty that nobody is going to wash a reflector and polish it, without wiping off the bulb.

It is apparent therefore that there is no occasion for worrying about the bulb if the reflector is kept clean; for then the bulb will be taken care of automatically.

President, ALLISON J. THOMPSON.
The Thompson Electric Co.,
Cleveland, Ohio.

Method of Locking a Push-Button Station to Prevent Starting Motor

IN ONE of the departments of our factory, we are using an automatic starter for controlling a motor that drives a machine which extends through two floors. The motor is started from either floor from push-button stations and can be started only when all stations are clear. When working on, or loading up the machine, the operator pushes the stop button down and turns the clip shown in the accompanying illustration, over it. Since the control stations are electrically interlocked, this prevents anyone from starting the motor from either station. A hole is punched in one end of the clip so that a padlock may be slipped through it, thus locking the clip in this position and, consequently, locking the push-button in the stop position.



This device can readily be made from sheet steel and will prevent many accidents.

The photograph, which was furnished by the National Safety Council, shows the method of locking a push-button switch in the stop position. A padlock may be slipped through the hole in the clip, thus preventing unauthorized persons from starting the motor while workmen are working on the machinery driven by it.

The clip is made of sheet steel and is riveted or bolted to the push-button cover so that it may be turned around the rivet or bolt as is shown in the illustration. The end of the clip adjacent to the push button is formed so as to fit over the button when it is pushed in.

Columbian Rope Co., H. H.
Auburn, N. Y.

Arrangement of Primary and Secondary Buses for Transformer Bank

MANY industrial works distribute their power supply at 550 volts and then transform it to 220 or 110 volts for use on the motors nearby. The transformers are usually placed outdoors on the ground. A very economical yet substantial arrangement of the high- and low-tension buses for such an installation is shown in the accompanying illustrations.

In Fig. 1 are shown two transformers connected open delta for supplying the 220-volt power required in the immediate vicinity. The 550-volt, primary bus is located on the wall behind the transformers. It consists of three single-conductor cables mounted on Pierce secondary racks (Hubbard & Co., Pittsburgh, Pa.) which are bolted to the face of 4-in. angle irons, which in turn are bolted to the wall by means

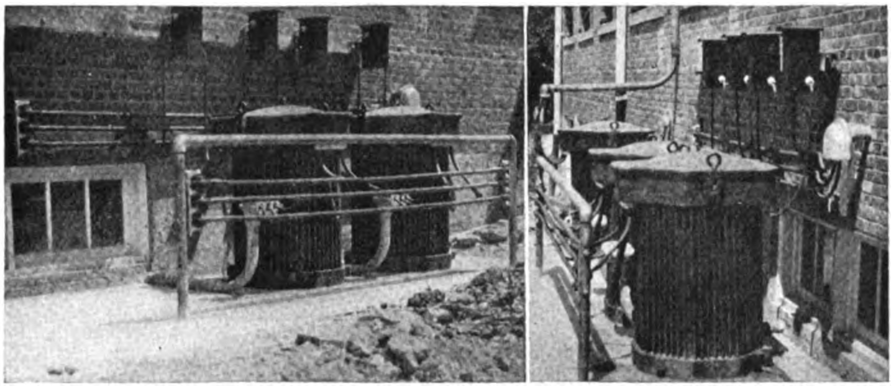


Fig. 1—The secondary bus of these transformers was mounted on a pipe frame-work.

In the left-hand illustration, may be seen how secondary racks were fastened to the pipe uprights in such a manner as to hold the buses made of single conductor cables. The right-hand illustration shows how a similar bus was mounted on the wall behind the transformers so as to supply the primary side of the transformers.

of through-bolts. When the cable buses are to be made up, the bolts fastening the Pierce secondary racks on one end are slacked off for about an inch and the bus cable made up as taut as possible in this position. The bolts on the slack secondary rack are then tightened up to the maximum which draws the buses up as tight as a "fiddle string." Thus tautness is obtained without the use of turnbuckles which take up much space and are not neat in appearance.

The 550-volt supply is delivered to the primary bus through wires in conduit as shown in the right-hand illustration of Fig. 1. A separate fuse cutout is provided for each primary lead to the individual transformers. These cutouts are mounted on an angle iron which is above the primary bus and attached to the wall behind the transformers.

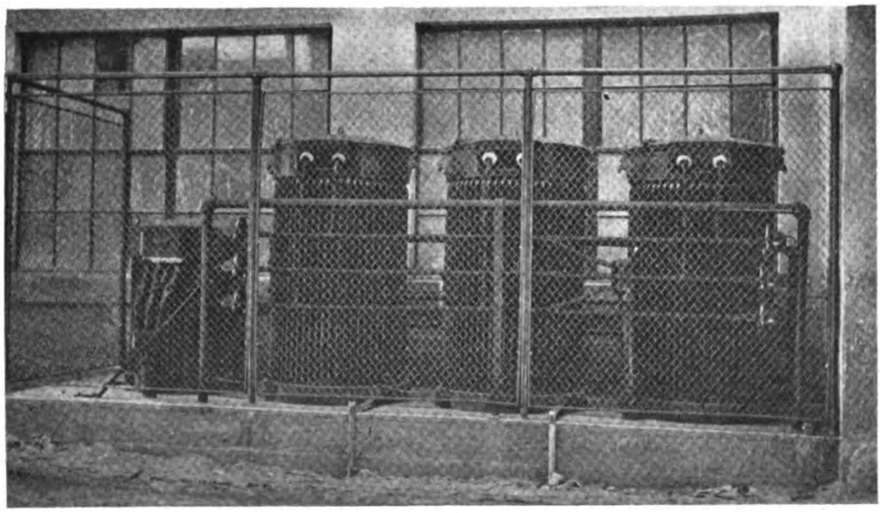
The arrangement of the secondary bus is unique. A pipe framework was mounted in front of the two transformers as is shown in the left-hand illustration of Fig. 1. A Pierce secondary rack is attached to each of the two pipe uprights and three single-conductor cables are strung to make the secondary bus, in a manner similar to that described for the primary bus. The pipe connecting the vertical members of the secondary-bus supports is provided, of course, for the sole purpose of giving something to pull against when the wires are tightened by the above mentioned method.

The secondary leads of the transformers are connected directly to the bus. Two feeders are shown connected to the secondary bus. They are in the two conduits running across the concrete floor on which the transformers are placed. In Fig. 2 is shown a similar arrangement for larger transformers. In this case the three large transformers are delta connected to supply the 220-volt power. The fourth transformer is a separate installation and supplies the 110-volt lighting system.

President, R. S. Huntington.
Huntington & Guerry,
Greenville, S. C.

Fig. 2—Another installation using a pipe frame-work to support the secondary bus.

Notice the wire guard or grillework placed around the entire installation to provide greater safety. Also note the thorough grounding of the transformer cases by copper straps connected to ground plates. The ground connections can be seen on the front side of the concrete foundation.



Shocks from Lights Caused by Leaky Transformer Case

THE following incident, which occurred about a year ago in a machine shop in one of the larger cities, may be of interest to the readers of Industrial Engineer. The street lines carried electrical energy at 2,200 volts, which was stepped down for domestic and industrial purposes. The machine shop mentioned operated its motors at 220 volts, three-phase, 60 cycles. The power transformer and the lighting-circuit transformer were both on the same pole in front of the shop, the pole having been set for this purpose and not to carry the power transmission lines.

One afternoon a workman in the grinding room reported to the superintendent that he was getting a shock from the lamp over his machine. The superintendent thanked the man, who had mentioned it as something of a joke, and said he would tell the electrician to go over the wires in the grinding room. Through some delay the electrician did not get around to it for several days and meanwhile there came a dark rainy day when lights had to be used quite generally.

This general turning on of lights started the fun. Men touched the keys and yelled; other men were knocked over. Fellow workmen laughed at those who had gotten a "shock" and, when taunted, tried the sockets themselves with the same result.

When the electrician was called, he made a hasty examination of the shop lines and could find nothing wrong. However, when he stood on a dry board and attempted to turn on a light (porcelain key on a porcelain socket), he was knocked against an adjoining partition. Realizing better than the rest that there was something radically wrong, he called up the line gang's office and the chief himself, skeptical and silent, showed up in a little while. This official refused to believe there was anything wrong and left saying that the boys imagined it, although he refused absolutely to try to turn on a light himself.

Not satisfied, the electrician called another department and got one of the meter testers to come out with a voltmeter. The floor in part of the machine shop was wood; the remainder was concrete. All of the floor was at the ground level. Selecting a socket where the concrete floor was right on the earth, the tester connected the meter between the socket and the floor. His instrument read 2,200 volts. He had found conclusively that there was something wrong.

When the line gang was forced by this test to look into the matter, they located it at the transformer. The latter was dry and entirely empty of oil, thus causing the insulation between the primary and secondary windings to fail and permitting the 2,200 volts to get on one of the low-voltage wires.

This is not, of course, a regular occurrence but it is worth watching out for and it goes to show that complaints about a "shock off of that light" ought not to be taken lightly. In this particular case, the oil had been leaking out gradually for some time. It was in the Spring and the branches of a maple tree swept the pole where the transformers were. The superintendent came right by the spot every day and he remarked, then, that he had noticed the spots on the sidewalk for some

time but thought they were from maple sap that had dropped from a broken branch above. DONALD A. HAMPSON.
Plant Superintendent,
Morgans and Wilcox Mfg. Co.
Middletown, N. Y.

Procedure for Inspecting and Maintaining Storage Batteries

THE operating code of the Philadelphia Electric Company contains the following instructions for treatment of cells whose voltage or specific gravity are seriously low:

1. When the plates of a cell become sulphated cut the cell out of service; substitute water for the electrolyte.
2. Charge the cell until there is no further increase in specific gravity.
3. If the sulphation is so deep as not to have been all removed by this operation, again substitute water for the electrolyte.
4. Charge the cell until there is no further increase in specific gravity.
5. Repeat this operation as often as may be necessary to remove the sulphation.
6. Bring up the specific gravity to the normal value by adding acid.
7. If the plates of a cell become short-circuited owing to bulging of the active material or foreign material between the plates, scrape the plates well with a stick. Remove the deposited material from the bottom of the jar.
8. If the plates of a cell become short-circuited owing to buckling, remove them from the cell and straighten them.

When scraping battery plates of accumulated materials a wooden stick should be used to avoid short-circuiting the plates. Owing to the considerable amount of moisture given off by a battery, the humidity in the battery room is very high and condensation occurs upon most objects, especially metal. This being acid in character causes corrosion of metal and also attacks the woodwork. Consequently acid-proof paint should be applied where possible, and vaseline should be used on parts such as connections between cells. Boiled linseed oil is also a good acid and moisture resistant for application to wood. Detailed instructions for cleaning and inspecting batteries, are as follows:

CLEANING AND INSPECTION

1. Wipe off glass covers, jars or tanks and all supporting insulation.
2. Keep the trays dry and clean.
3. After cleaning the wood tanks wipe them with a cloth saturated with boiled linseed oil.
4. Make sure that the overhanging lead on lead-lined tanks is pulled away from the sides of the tanks so that condensation will drop to the floor and not run down the sides of the tanks.
5. Coat the inside of the glass jars with vaseline about ½ in. down from the top.
6. Copper busbars and any other metal, except the connection between cells, which are exposed to acid fumes must be coated with acid-proof paint.
7. Wooden racks should have the same treatment.
8. The connections between cells should have a light coat of vaseline.
9. Wash the racks and the floor occasionally with bicarbonate of soda to prevent damage from acid.
10. Inspect the cells frequently for sulphation and internal short circuits.
11. Keep all material from bridging the space between the plates or building up on the bottom of the jar or tank. A wooden stick passed between the plates and scraped over the bottom of the jar or tank will prevent a dangerous accumulation of such material. Never use a piece of metal for this purpose.
12. Fill the automatic pilot cell filler as often as is necessary to replace evaporation.

Use of Extension Reel to Prevent Interruption of Telephone Service

ONE time when I was employed on an electrically-driven dredger, we were constantly bothered by interruption of the telephone service to the booster-station end of the shore line, when blow-outs of the rubber connections on the pontoon line occurred, or when the pontoon line pulled apart in stormy weather—just when telephone service was needed the most. The wires connecting the telephone stations were laid along the pontoons and when these were pulled apart the telephone lines broke also.

To get around this difficulty, I constructed a reel for the telephone wire and anchored it on the first pontoon; then when the pontoon line broke, the wire would just pay out and service would not be interrupted. Inasmuch as this wire reel could be built in almost any size and used to extend the range of portable tools or other light equipment, a description of it may be useful to other readers.

The illustration shows how this reel was made from an ordinary wooden reel upon which armature or banding wire is shipped.

An iron pipe was fitted tightly in the hole of the reel, to serve as a support, after holes for the conductor had been drilled through the reel and the pipe. The collector rings were made of brass tubing and were sawed off so that a lip was left, to which the telephone wire connections were soldered. These rings were put on by winding empire tape tightly around the pipe until the rings would fit very snugly over it by twisting them in the direction the tape was wound on.

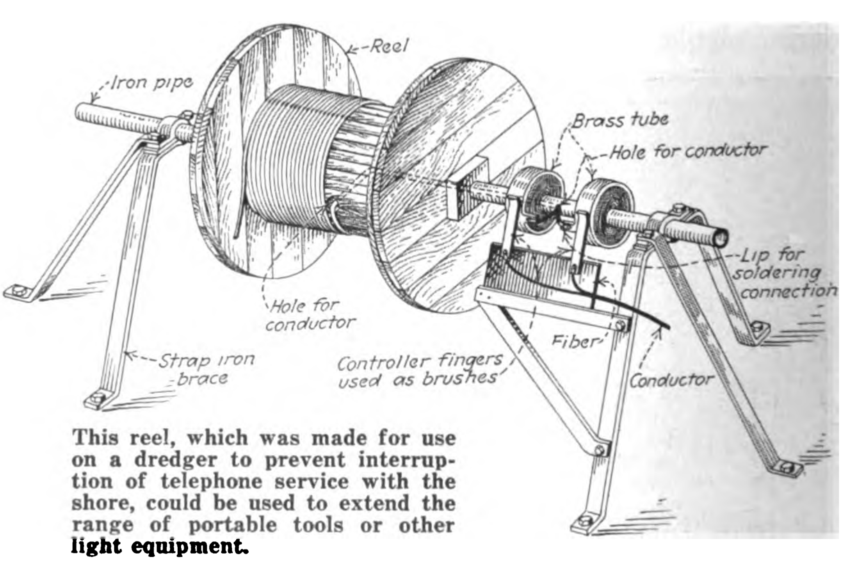
Probably a better looking job could have been made by mounting the collector rings on fibre disks turned down to the proper diameter, although rings mounted as described served our purpose well enough. When both rings were in place the lips were staggered. Another hole for the conductor was drilled in the iron pipe between the collector rings.

The pipe and reel were then mounted in simple bearings on a strap-iron support of the form shown in the illustration. These supports were easily made and were very strong.

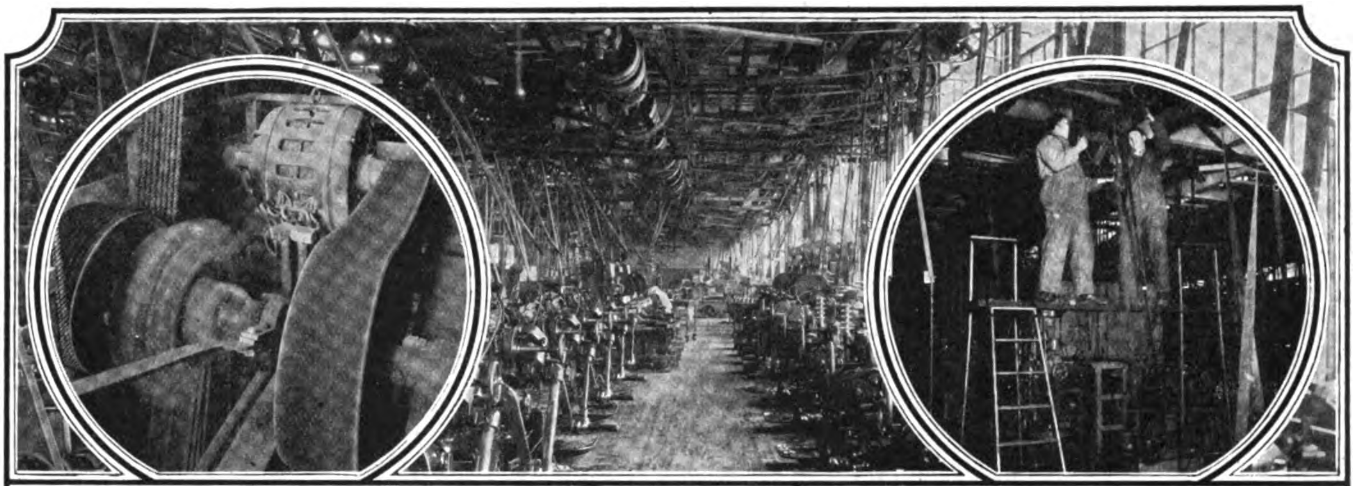
The brushes for the collector rings were made from old controller fingers with the solid copper tips removed. The strips of leaf copper remaining were riveted together and ground to fit the rings. These brushes were then bolted, spaced the proper distance apart, to a fibre block which, in turn, was securely bolted to the strap-iron bearing support.

The two wires comprising the dredger end of the telephone line were soldered to the collector ring brushes. One end of the conductor which was to be mounted on the reel was passed through the hole in the middle of the reel, through the pipe and out through the hole in the pipe between the collector rings, to which the two wires were soldered. The remainder of the wire was then wound up on the reel. The line to the shore was stretched along the pontoon line and passed through wired loops fastened to the pontoon pipe cleats. After this wire reel was put into service there was no further interruption of telephone communication with the shore.

Oakland, Calif. S. H. SAMUELS.



This reel, which was made for use on a dredger to prevent interruption of telephone service with the shore, could be used to extend the range of portable tools or other light equipment.



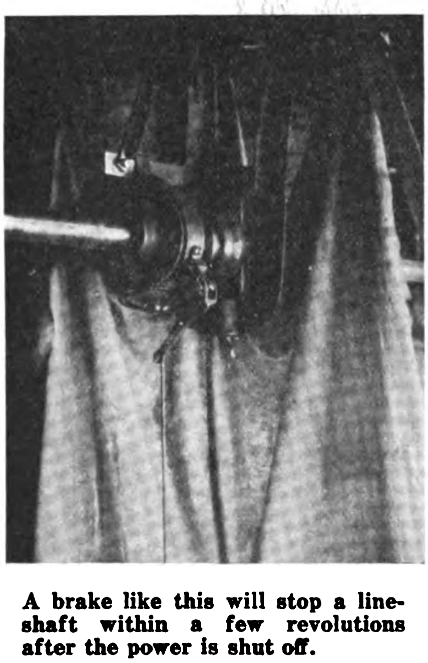
Mechanical Maintenance of Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Simple Brake to Stop Lineshaft Quickly in Emergency

A BRAKE that we installed on our machine shop line shafting is shown in the illustration. There are 180 ft. of shafting that drive nearly eighty countershafts. More or less work has to be done while shafts are running at normal speed or slackened for the occasion and there is likewise always the possibility of belts getting tangled up. A belt that gets caught may not injure a person, but after it breaks, flying ends may cause havoc until the shaft is stopped.

No means are provided to stop shafts in modern installations. It is not considered necessary—what is important is to make them run as easily, with as little power consumption, as possible and to this end the expense of ball bearings and non-slipping drives become justifiable. But the minute the power is shut off, the shaft load becomes unimportant—the shaft may run one minute or five in coming to a stop.



A brake like this will stop a lineshaft within a few revolutions after the power is shut off.

In an emergency, a brake is highly desirable. This one of ours has been used several times with gratifying results; one of the times being when a man got his hand tangled in a loose hanging belt, so that the brake changed what might have been a serious accident to merely a bad scare for everyone concerned. When it is necessary to stop the shaft during working hours to put on a belt, nearly a minute of each man's time is saved by being able to stop the shaft quickly.

The brake shown was made from an automobile brake. The supports and anchor were forged for this purpose and are bolted to a beam. Such a brake needs to be well supported in order to resist the tendency to wrap around the shaft when it is operated and also to keep it away from the drum, to avoid friction and heat. A lineshaft coupling or a small pulley may be used as the brake drum. The rod by which the brake is operated terminates in a handle that can be conveniently reached by a person standing on the floor. DONALD A. HAMPSON.

Plant Superintendent,
Morgans and Wilcox Mfg. Co.,
Middletown, N. Y.

Advantages of Short Center Belt Drives in Industrial Plants

BELT capacity is ordinarily estimated with the assumption that the belt is in contact with at least 180 deg. of pulley surface. Where less contact is made less power can be transmitted with the belt at the same tension. Short-center drives require some means of increasing the belt wrap on the smaller pulley so that it will get more surface in contact with the small pulley and permit full capacity of transmission without excessive tension. One method of obtaining this is through special, belt-tensioning devices; one type of these is the "Pulmax Drive" designed by the engineers of the Bird Machine Co., South Walpole, Mass.

Drives of this general type are of particular value for transmission between pulleys that are unequal in size. The greater the difference in pulley size or the nearer the pulleys to each other, the greater the importance of this drive. With it higher efficiencies are now obtainable between a large and small pulley, placed close together, than are obtained from most ordinary drives that are regarded as ideal. In addition, with this type of drive the user of belts need no longer worry about relative pulley sizes, position of pulleys, vertical or horizontal, belt slip, which is the driver and which the driven pulley, or placing the pulling side on the top or bottom when planning a belt drive.

A typical drive of this sort of which the Pulmax is an example is shown in an illustration on the next page and consists of a roller (A) assembled on an arm (B) which in turn is mounted on a shaft (C) supported by a suitable pedestal. The roller is held against the slack side of the belt by counterweight (D). Some types of this drive have the roller assembled on two arms mounted on a shaft supported by one or two pedestals. The roller pulley is on a revolving shaft mounted on ball bearings. The shaft for the pedestal to which the arm is fastened is free to oscillate in a bearing in the head of the pedestal.

To go into detail on all of the advantages of this type of drive and into its theory and practice would consume much space. Below are given some of the principal advantages with a few brief explanatory remarks. One advantage, for example, is space saving. An excellent illustration of how this type of drive saves space is shown by the diagram on the next page.

Here original pulley centers of 19 ft. 3¼ in. were reduced to 4 ft. 6 in. This resulted in a considerable saving in space, belt and in the time formerly required for adjusting the old belt to keep it tight. The original installation was constantly giving trouble because of belt adjustment and belt wear. Except for an occasional oiling, the motor, drive and belt have not been touched since the installation was made in December, 1921.

Some of the other advantages may be discussed with brief explanations as follows: Pulleys may be located in almost any relation to each other as the line through the center of the pulleys can be at any angle to the floor line. Also, the belt can run in either direction and the unit is suitable for nearly all belt drives. The unit is entirely mechanical and automatic in its performance and needs no attention aside from occasional oiling, as it does not have complicated mechanism. This and the minimum bearing friction give a low cost of upkeep.

Because belts do not have to be so tight there is less wear, hence longer belt life. The shorter belts necessary give a lower belt cost. Sometimes narrower belts may be used to obtain the required output or increased capacity obtained from an installation. Belt clamps are not needed for tensioning or for splicing. This simplifies the splicing problem and saves much time. Also, as tension is maintained by the drive the belt does not need frequent attention. Arcs of contact of 225 deg. and more are frequently obtained and ordinarily difficult drives operated without applying belt dressings for the purpose of preventing slippage.

Endless belts are easily placed on or removed from the pulleys as the tension is applied after the belt is in place. This avoids the harmful practice of running a large belt onto a pulley by first forcing one of the edges to catch and then running the belt on either by hand or by power. Where overhung pulleys are used the belts can be made up endless by the belt manufacturer.

Great accuracy as to belt length is not so necessary with the special short-center drive as with the old style of drive. Also endless belts usually operate with less vibration. This type of short-center drive is elastic instead of rigid and so absorbs shocks and vibration which makes it an excellent drive for severe operating conditions. Also there is no flapping or waving of the belt, regardless of speed or load conditions. This also usually helps prevent vibration.

Still another advantage lies in the fact that as the operation does not require the maintaining of a high tension in the belt, the effectiveness of the drive is not affected by atmospheric conditions such as temperature and humidity nor by seasonal changes.

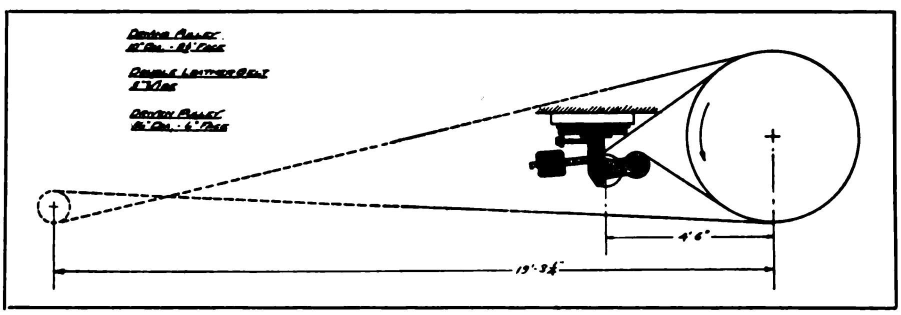
Sometimes important savings may be made by making additions and new construction unnecessary. In one instance short pulley centers gave enough additional space to save the cost of constructing an addition to a crusher building. Where direct-connected steam engines are replaced by motors and short-center drives, no more floor space, and frequently less, is required than formerly. Sometimes savings can be made in the cost of the equipment to which it is connected. For example, in some cases there is a reduced first cost of generators and motors because of the higher speeds which may be used. In some cases the entire cost of the special drive has been covered by the lowered price of the generator or motor which could not have been used with the ordinary open drive.

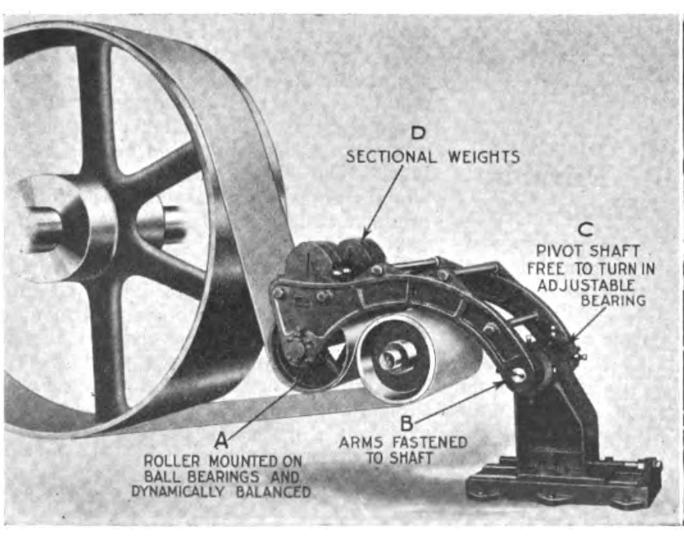
The first cost is low and the savings are further increased by reduced operating costs. Also, the speed reduction can generally be made in one step without extra countershafts or jackshafts. As this type of drive is simple it is easily and quickly installed by any man of average mechanical ability. Since there is nothing to get out of order the maintenance cost is low. Devices of this type are so simple that they can be operated by anyone as there is nothing to adjust. Bearing pressures, speeds and tensions may be determined so that the completed installation can be scientifically and practically correct. The larger contact of the belt on the pulley makes it unnecessary to lag the belt with leather or other materials. Iron, steel, wood, paper or any kind of pulley may be used. With the lower belt tension both belt and bearings will last longer. Also oil cannot leak from the ball bearing on the roller pulley shaft onto the belt and spoil it.

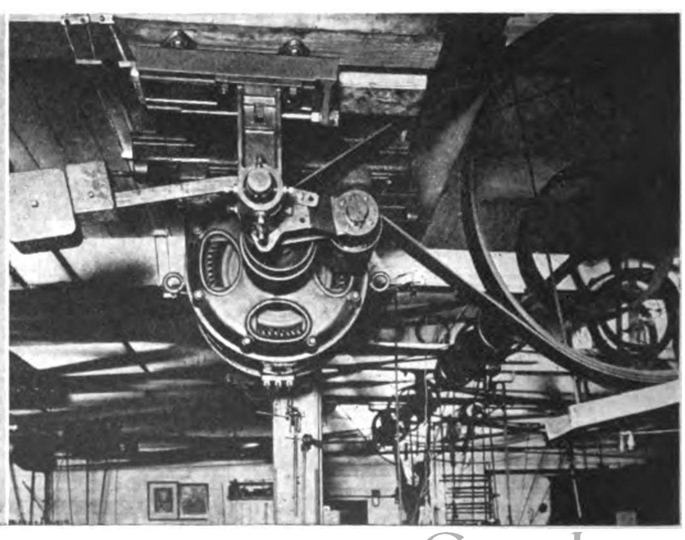
Operation at lower tension and the elimination of slip increase the efficiency of the drive over the whole range from light load to peak load. The minimum belt tension is constantly maintained. The initial tension on the slack side is a predetermined, fixed quantity. After its determination the tension on the slack side is practically held at that point. The old rule "make the lower side the pulling side" does not hold here. With drives of this type either the top or bottom may be the pulling side and with equally high efficiency. In addition, vertical drives are as readily handled as horizontal drives.

Construction details of a Pulmax belt drive and one lineshaft drive installation.

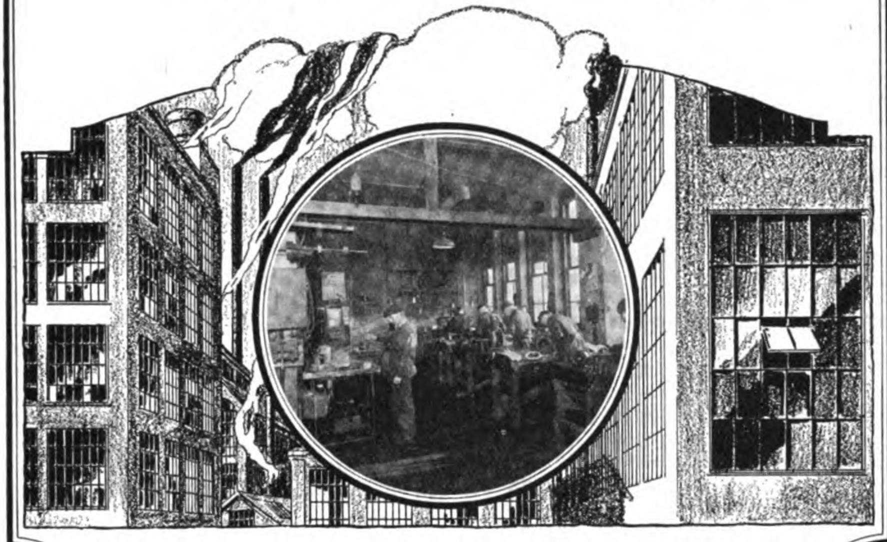
This drive, as shown in the illustration below, consists of the addition of a special pulley on a pivoted arm which increases the arc of contact of the belt upon the small pulley. The sketch shows how a lineshaft drive was shortened by means of a Pulmax drive. The lower illustration at the right shows the same installation as given in the sketch, which was made in Dec., 1921. The belt and drive have required no attention since, except oiling the pulley. Before this was installed the belt had to be tightened frequently.







In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Tests for All-Through Drying of Insulating Varnishes

A STATEMENT appearing in the article by the writer entitled, "When Analyzing Coil Troubles," and published in the July issue of INDUSTRIAL ENGINEER was challenged on page 398 of the August issue. The original statement in my article read as follows:

"Some materials have been sold on the claim that they will dry from the inside out and that, therefore, drying can be obtained all the way through. These materials have not been a success as it has been definitely proved that they will also form a skin over the outside surface, and when such a skin is formed the oxidation of the varnish base is stopped. Rather than select a material which must be sold by false claims it is much wiser to see what can be done towards remedying the difficulty by a proper method of treating the coils after the varnish has been applied."

Rather than enter into any discussion of the merits of the case I will describe two very simple experiments, by means of which anyone interested in the subject may demonstrate for himself whether any baking varnish dries throughout.

(1) Dip a sheet of bond paper 4 in. wide by 18 in. long and .0025 in. thick in the varnish in question and withdraw vertically at a slow, uniform rate of speed. Allow it to drain vertically for one-half hour; then bake in a well ventilated oven until dry. Upon removal from the oven an accumulation or bead of the varnish will be found to be formed on the lower edge. Tear this bead across and note the condition of the varnish, that is, whether any undried or only partially oxidized varnish can be squeezed out by the pressure of the fingers.

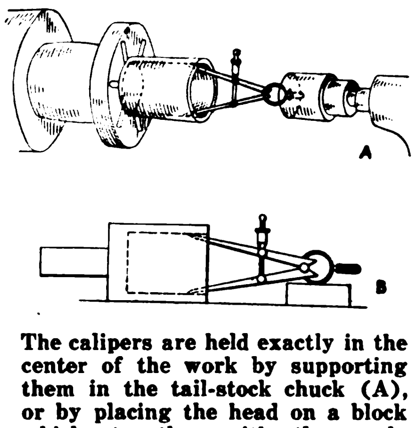
(2) Fill a small tin container about 3 in. in diameter with varnish to a depth of ¼ in. Place this in the drying oven and bake for 12 to 24 hrs. Examine the surface with the finger and note whether the same degree of toughness exists throughout or whether there is a skin over the surface. Breaking of the film will show very quickly the condition of the varnish underneath.

The writer believes that if these tests are carefully carried out the results will be the same as his own. In any case they should provide the reader with ample proof of the all-through drying qualities of any particular material.

H. L. HAZELTINE.
Engineer of Insulation,
The Sterling Varnish Co.,
Pittsburgh, Pa.

Accurate Method of Calipering Internal Work

THE difficulty of obtaining exact measurements with inside calipers are known to every mechanic. Where there are several thousandths leeway not much trouble is experienced, but when close limits must be maintained the situation often becomes tense, due to the difficulty of holding the calipers exactly centered throughout the entire length.



The calipers are held exactly in the center of the work by supporting them in the tail-stock chuck (A), or by placing the head on a block which, together with the work, rests on a surface plate (B).

An easy way to avoid these troubles and obtain more accurate measurements in less time than is ordinarily required is to support the handle of the calipers in the tail-stock chuck, as shown at (A) in the illustration, while taking measurements. The chuck is closed until it makes a loose sliding fit for the handle of the tool. By holding the caliper points in a vertical plane and sliding the handle back and forth in the chuck, it is possible to obtain accurate and dependable measurements almost instantly, as the support at the rear end eliminates about 80 per cent of the ordinary causes of error.

Where the work must be examined after it has been removed from the lathe, the same results may be obtained by placing both the work and a rectangular block for supporting the head of the calipers on a surface plate, as in (B). The spring clip of the calipers should in this case be placed on the block, as this gives a firm support, and the block must, of course, be about the right height to bring the handle of the calipers center with the work. In this case, either the calipers can be slid over the block, or the block and calipers together can be slid along toward and from the work.

Santa Ana, Calif. S. H.

Handling Repairs Profitably in the Plant Repair Shop

I HAVE read with much interest the "Topics Discussed by Steel Men" on page 464 of the October issue of INDUSTRIAL ENGINEER. Having been in maintenance work myself for several years I am prompted to make the following comments on the subjects discussed.

I notice in the article mentioned that several engineers have different opinions on the same subjects and one naturally wonders why there is this diversity of opinion. For instance, if "A" finds it profitable to rebuild commutators in his own shop but finds coil making unprofitable, and "B" finds the reverse, etc., why do the opinions differ? In all probability if "A" and "B" were doing the work themselves or were directly supervising it, they would both find it profitable to do both kinds of work.

I have been through the mechanical machine shop and electrical maintenance and have taken considerable pride in handling any job which came along whether I had ever seen it before or not, and doing it successfully, but I suppose that is why I am not doing it now.

Work which has come under my supervision, in the machinist line, ranges all the way from cylinder-lock repairing to shrinking tires on a locomotive, tool making, indexing and heat treating, turning large crankshafts and scraping in 30-in. valve seats, and from winding fan motor armatures up to those of 300-hp. size, both d. c. and a. c. The latter work included coil making,

rebuilding commutators, dipping, baking and practically everything connected with motor repairs.

As far as cost is concerned no one has ever taken the trouble to figure overhead expenses for the repair shop, but I keep an accurate record of time and material and if this cost is one-half or less than an outside price, it is usually done in our shop.

Our equipment is not expensive but electrical energy for power and light is generated and, due to our many uses for exhaust steam, is considered much cheaper than purchased power. But service is paramount to everything else. Much of our equipment cannot be down for more than one or two hours without special arrangement. When motors decide to burn out, they do not wait for special arrangements to be made; therefore, we are forced to make our own coils, rebuild our commutators, etc., and carry a large stock of spare armatures, bearings, pinions, and the like. While the expense of keeping this stock is considerable, I think it is more than offset by having plenty of time to do a thorough job of winding or repairing. My experience is that a job of winding which is hustled through at top speed, perhaps the winder working overtime all night, with a half-way job of painting using the quickest air-drying varnish obtainable, is a costly job.

Compare the same repair job with one when more time is available. The winder will use more care and thought, if he is at all conscientious and the job will be better insulated; coils and commutator all tested out properly with megger; undercut, if this is necessary, dipped in high-class baking varnish with plenty of time for baking and, if necessary, a double dip and baking. Whatever length of time the first armature requires, the second will run four times as long and will cost one-fifth more and be worth it.

There is one more thing regarding the making or buying of coils, bearings, etc. I have waited from six weeks to three months for various parts to come from one of the largest manufacturers of electrical equipment in this country, and that length of time does not go in our plant. This makes it necessary to have the equipment for handling these repair parts and we use it, get familiar with it and devise ways and means to do this work as good and as cheaply as possible. Much of this work figures for time and material less than one-third of the manufacturer's price, with the advantage of making the repairs in a few hours' time. Furthermore, electrical troubles with armatures have been reduced about 50 per cent within eighteen months at our plant, which, after all, is the justification of our procedure.

There is probably more vital detail work connected with armature winding and repair than with any other repair work in an industrial plant. For instance, a commutator may be tested with a lampbank and show clear. But put a megger on it and it will show a different story. The average reading may be 50 megohms with two bars showing 6,000 ohms. This would show clear with a lamp test at 250 volts, but something is certainly wrong and if it is not attended to, the result is a burned-out coil in a short time.

Men who handle repair work must use a lot of common sense and watch for every possible cause of trouble. In wire-wound armatures care must be taken to prevent wires from crossing one another without extra insulation between them. Be sure that all leads are run parallel, that there are no burrs on the inside of teeth and that slot insulation is not damaged when putting coils in. Keep coil shapers and hammers away from an armature as much as possible; shape the coil and spread it with the hands as much as you can before putting it in the slots. Also, seal both ends of the commutator with just a small amount of Bakelite cement before winding, to keep out dirt and oil. Be sure the bands are tight while being soldered and that the first and last turn are bent around the clip and caught with solder.

A most careful inspection when the work is completed will not always show up defects and with the average help available today if these details are not watched for while the winding is going on, more or less trouble is bound to follow.

A man to have charge of electrical equipment, repairs, and winding must have some natural mechanical and electrical ability coupled with theoretical and practical knowledge in order to compete successfully with large repair shops, both in cost and lasting equipment.

Where to find the above gem is always a question. The man who highly educates himself technically does not want to dirty his hands in the practical end, and the man who is the real practical stuff does not find the time to devote to a study of theoretical details of electrical and mechanical work. The few who are qualified to supervise these vital details are soon graduated to higher positions, leaving a place to be filled by one who may be less capable at the start but has chances of doing good work if he will properly apply himself.

CHESTER A. WILLIAMS.
Electrical Department,
Providence Gas Company,
Providence, R. I.

How to Make Adjustable Bench for Repair Work

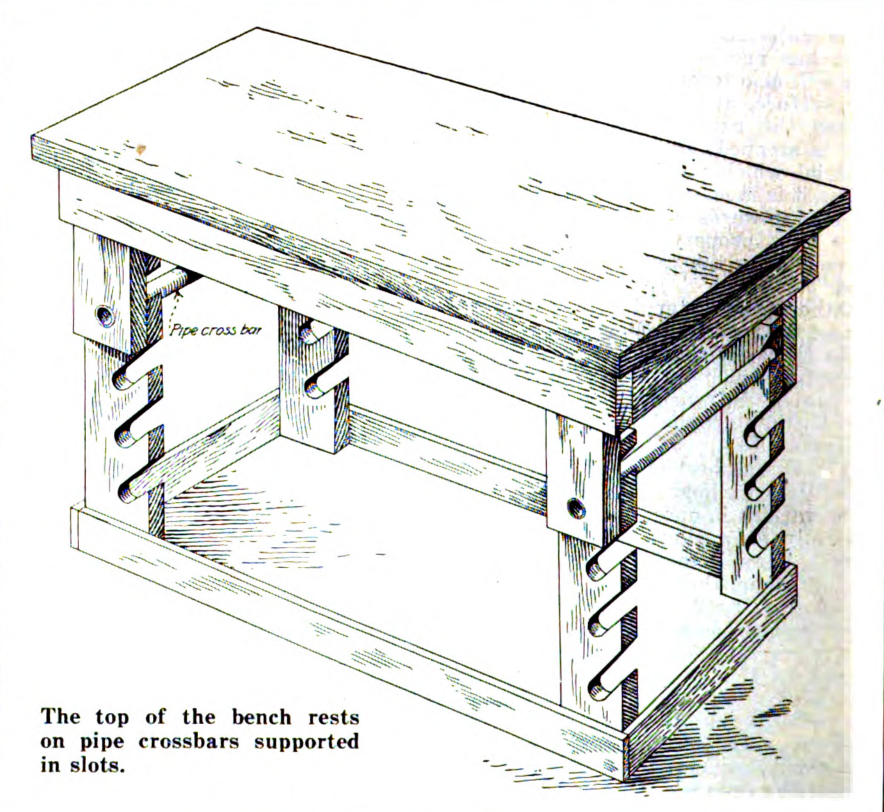
THE objectionable features of a bench which is too high or too low are overcome with the bench construction shown in the illustration. This is suitable for almost any kind of repair or construction work in wood or metal. Inasmuch as the height of the top can be adjusted, this bench can be used with equal convenience when working upon large parts which require that a low bench be used so that the workmen can reach the parts without using a footstool, as well as when doing small assembly or other work in which the top of the bench must be reasonably high in order to avoid the necessity of stooping to an uncomfortable position.

As shown in the illustration, the top is similar to that of the ordinary bench, while the legs are made up separately into a fixed stand.

Between the legs of the bench at each end, a pipe crossbar is placed as shown in the sketch. Diagonal slots are made in the legs at intervals of two or three inches. The bench top is supported by placing the cross bars in the slot.

Raising or lowering of the top is a simple matter of shifting the position of the crossbars in the slots.

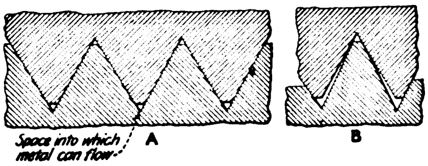
Washington, D. C. G. A. LUERS.



The top of the bench rests on pipe crossbars supported in slots.

How to Make Nuts Tight Fitting and Prevent Stripping

IT IS highly desirable to have tight fitting nuts on all machines, particularly punches and the like, where normal jarring tends to work them loose. As a rule nuts are put on to stay, but where parts have to be changed occasionally, as when changing bolsters or replacing worn rolls, the nuts that were



The threads are cut so as to leave a small space at the bottom into which metal can flow.

originally close fitting soon become loose—a condition which is highly undesirable.

As a matter of fact, few threads produced without special thought in the matter will stand screwing and unscrewing of a nut more than two or three times without loosening up. The usual directions given to machinists are "make smooth threads and get a tight fit." And where directions are followed to the letter, stripped threads may be expected in a third of the applications.

There is a method of making threaded fits which will give a lasting fit under practically any number of removals, a fit which is tight and remains so, which is proof against stripping. In the illustration (A) shows the outline of this thread.

The secret of this "kink" lies in the flow of metals under pressure. It will be noted that there is a space at both top and bottom of the thread shape. Into this space the metal can flow when a tight nut is screwed on. If the nut and bolt are well oiled, any fit which can be screwed on with a wrench and not twist off the bolt can be made without stripping. It will be found that stripped threads (either with a die or a nut) result from clogging at the top or the bottom of the thread. The space should be there, in accordance with good practice, but it seldom actually is, due to lack of attention. The importance of this space in making permanent tight fits is not generally known.

A slight variation from this method, is that the male and female portions are cut at different angles, is shown exaggerated at (B). With such threads there is more room for flow; consequently a tighter fit is possible.

DONALD A. HAMPSON.

Plant Superintendent,
Morgans and Wilcox Mfg. Co.
Middletown, N. Y.

Truck Facilitates Handling of Heavy Armatures

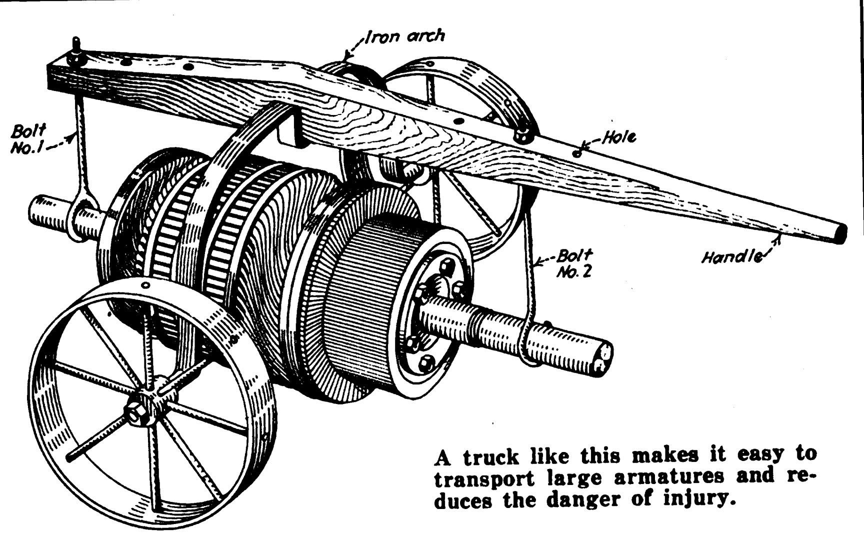
CARRYING heavy armatures to and from the repair shop and around the plant without injuring them is not an easy matter. Everyone who has handled armatures on a flat truck knows that they will sometimes roll off in spite of all precautions to prevent this mishap. Also, it does not take much to damage the commutator or coils.

The illustration shows a very handy truck which is used in the repair shop of a large plant, and has saved its cost many times over by preventing injury to armatures and making it easy to transport them around the plant.

Two iron wheels were salvaged from the junk pile and joined, as shown in the illustration, by a piece of heavy bar iron bent in the form of an arch. The ends were turned down to form an axle for the wheels. A groove or recess was forged in the center of the arch, into which a heavy hardwood handle was fitted. The handle is, of course, securely bolted to the arch. Two bolts in the handle support the armature. The first bolt, No. 1, is a long eyebolt, although it would probably be advisable, for convenience in handling, to make this bolt with a hook on the end. The other bolt should be made with a hook in the end and should preferably be suspended from an eyebolt, so that it will be free to swing. Both of the supporting bolts should be fairly long and threaded for a good portion of their length so that they can be raised or lowered as desired.

Several holes for these bolts should be bored in the handle so that different sizes of armatures can be accommodated.

Oakland, Calif. S. H. SAMUELS.



A truck like this makes it easy to transport large armatures and reduces the danger of injury.

Repairing Electric Elevators

(*Continued from page 518*)

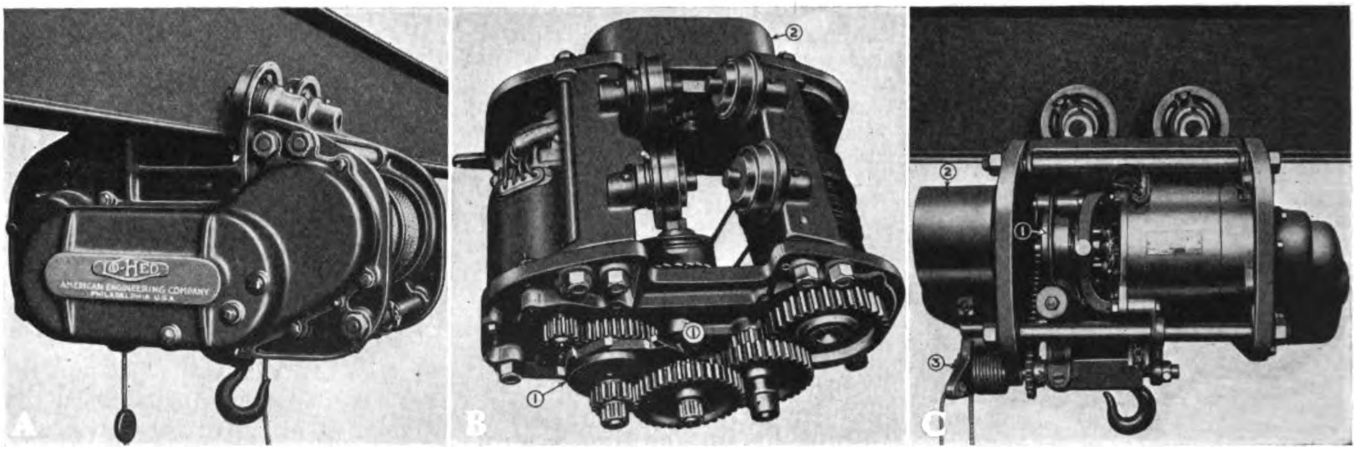
of used and rebuilt motors and the renting of motors came about in similar fashion. In the course of a few years we had accumulated a large number of motors which had come to us by direct purchase or through the replacement of existing installations with motors of greater capacity, and so on. As a matter of service to our customers we frequently had to install one of our own motors temporarily in the place of a damaged motor which was being repaired. In addition, we received many inquiries from individuals and concerns who, for one reason or another, wished to rent one or more motors for a time.

Starting in a rather small way, these branches of our business have grown to considerable proportions, and aside from the profits which they have made they have been of material assistance in carrying on the elevator repair and maintenance work which is the backbone of our business.

Motor rental is handled, in general, in the same way as has been outlined in the preceding pages. That is, when we receive an inquiry for the rental of a motor, the form shown in Fig. 2 *A* is made out and filed. This shows the price quoted. If the inquiry comes from a territory covered by one of our salesmen, he is given the white copy of the form and follows up the inquiry in person. Otherwise the rental price is confirmed in a letter. If our proposition is accepted the Rental Contract shown in Fig. 4 *F* is drawn up and signed by the customer and an official of our company.

In our experience we have found this form of contract very satisfactory as it covers every phase of such a transaction so completely that there is practically no opportunity for any misunderstanding or disagreement to arise regarding the rights and duties of each party to the contract.

That is an important consideration in any transaction.



Operation of Small Hoists

(*Continued from page 530*)

open the electrical circuit to the actuating coil of the contactor, this being known as the pilot-circuit type limit switch. The main-circuit type of switch is the more positive, but must be made heavy enough to withstand the burning due to opening the motor circuit, whereas the pilot-circuit type may be relatively small, since it handles only the actuating-coil current.

The table on page 530 gives a summary of various accessories used on small electric hoists, indicating their relation to each other.

This is a very compact arrangement of a small hoist having manual control with both lowering and holding brakes.

In illustration *A* is shown the hoist assembled complete. In *B* the enclosures have been removed so as to show the mechanism. At (1) is the mechanical lowering brake which is of the screw and disc type. The motor is shown at the left and the cable drum is opposite at the right. The controller is at (2) in both *B* and *C*. It is operated from a chain which is driven by the sprocket on the control arm (3) in illustration *C*. At (1) in *C* is shown the holding brake which is operated mechanically by the control arm (3). The limit stop also sets this brake in case of overtravel.

Laying Out Wave Windings

(*Continued from page 537*)

adjacent to and fall on the left side of the A_1 lead. In other words, they are in a counter-clockwise direction from A_1. These two short-pitch connections are in the first section of which A_1 is the starting lead. Likewise, there are two short-pitch connections in a similar position with reference to A_2. The latter are the short-pitch connections for the second section of which A_2 is the finishing lead. The same will be found to be true of the short-pitch connections in the second phase. This gives:

Rule 13—Adjacent to and in a counter-clockwise direction from the starting lead of the first section of a phase, will be found the slots from which start the short-pitch connections for that section, and the companion slots will be one short pitch away measured in a counter-clockwise direction for left-hand coils and measured in a clockwise direction for right-hand coils. Also, adjacent to and in a counter-clockwise direction from the finishing lead of the second section of a phase, will be found the slots from which start the short-pitch connections of the second section. The conductor adjacent to the starting or finishing lead will be a top conductor if the starting or finishing lead is a top conductor, and the other conductor to which the short pitch connects will be a bottom conductor if the first conductor is a top conductor, or *vice versa.* This applies to a left-hand winding. In the case of a right-hand winding, the short-pitch connections will start from slots in a clockwise direction from the starting or finishing lead.

(23) According to *Rule 13* and since A_1 falls in slot *1*, the first short pitch will connect the top conductor in slot *32* and the bottom conductor one short pitch measured in a counter-clockwise direction from slot *32*; that is, in slot *25*. According to *Rule 5*, there will be three short-pitch connections in the first section. These will be adjacent to each other; hence the top conductors in slots *32*, *31* and *30* will be connected by short-pitch connections to the bottom conductors in slots *25*, *24* and *23*, respectively. The location of the short-pitch connections for the second section of the same phase is found in a similar manner. The A_2 lead connects to the top conductor in slot *25*. Hence, a short-pitch connection will be made between the top conductor in slot *24* and the bottom conductor in a slot one short pitch measured in a counter-clockwise direction from slot *24*, that is, in slot *17*. As explained above, there are three short-pitch connections, hence, the top conductor in slots *24*, *23* and *22* will be connected by short-pitch connections to the bottom conductors in slots *17*, *16* and *15* respectively. Since the starting lead, B_1 of the first section of the second phase is in slot *21*, the short-pitch connections are in a similar manner found to be between the top conductors in slots *20*, *19* and *18* and the bottom conductors in slots *13*, *12* and *11*, respectively. Likewise, since B_2 falls in slot *13*, the short-pitch connections for the second section of the second phase are found to connect the top conductors in slots *12*, *11* and *10* with the bottom conductors in slots *5*, *4* and *3* respectively. This data checks that given in the third line, eleventh column of Table I.

The three-phase winding can be laid out in the same manner, except that to pick up the conductor to which the start of the C phase is connected, we must measure in a counter-clockwise direction from the A_1 lead a distance equal to twice the front pitch plus twice the number of coils per group. Also, the start of the B phase will be in a slot that is a number of slots measured in a counter-clockwise direction from the A_1 slot, equal to the front pitch plus the number of coils per group. If the winding is right-hand, the distance will be measured in a clockwise direction.

The following is the calculation for the layout of a series-star winding for a three-phase, four-pole motor having forty-eight slots and forty-eight coils:

(1) Number of slots—48.
(2) Number of phases—3.
(3) Number of poles—4.
(4) Number of coils—48.
(5) Number of sections, according to *Rule 3*, equals $2 \times 3 = 6$.
(6) Number of coil groups, according to *Rule 4* equals $3 \times 4 = 12$.
(7) Number of coils per section equals $48 \div 6 = 8$, as is given in the third line, second column of Table VI.
(8) Number of coils per group

equals $48 \div 12 = 4$, as is given in the third line, third column of Table VI.

(9) Number of short-pitch connections, according to *Rule 5*, will equal $[(48 \div 4) \div 3] - 1 = 3$.

(10) The total winding pitch equals $48 \div 2 = 24$.

(11) The back pitch is equal to $24 \div 2 = 12$, or a pitch of 1-and-13, as is given in the third line, fourth column of Table VI.

(12) The front pitch is equal to $24 - 12 = 12$, or a pitch of 1-and-13.

(13) The pick-up pitch is equal to $12 + 4 - 1 = 15$, or a pick-up pitch of 1-and-16.

(14) The short pitch is equal to $12 - 1 = 11$.

(15) This winding is to be wound left hand and the line leads are to connect to top conductors in the slots; therefore, the A_1 lead will connect to the top conductor in slot *1*, which is the value given in the third line, fifth column of Table VI.

(16) The B_1 lead will fall in a slot measured in a counter-clockwise direction from the A_1 slot, a distance equal to the front pitch plus the number of coils per group, or $12 + 4 = 16$. Therefore, the B_1 lead will fall in $1 + 16 =$ slot *17*, which is the value given in the third line, sixth column of Table VI.

(17) The C_1 lead will fall in a slot measured in a counter-clockwise direction from the A_1 slot, a distance equal to two front pitches plus twice the number of coils per group, or $(2 \times 12) + (2 \times 4) = 32$. Therefore, the C_1 lead will fall in $1 + 32 =$ slot *33*, which is the value given in the third line, seventh column of Table VI.

(18) The A_2 lead will connect to a top conductor in a slot that is a front pitch measured in a counter-clockwise direction from the A_1 lead. Therefore, the A_2 lead will fall in $49 - 12 =$ slot *37*, as is given in third line, eighth column of Table VI.

(19) Likewise, the B_2 lead will fall in $17 - 12 =$ slot *5*, as given in the third line, ninth column of Table VI.

(20) Likewise, the C_2 lead will fall in $33 - 12 =$ slot *21*, as given in the third line, tenth column of Table VI.

(21) As stated in item 19 in the preceding calculation and according to *Rule 7* the R_1 reversing jumper lead will fall a distance measured in a counter-clockwise direction from the A_1 lead equal to one pick-up pitch; that is, the R_1 lead will fall in $49 - 15 =$ slot *34*. Therefore, the R_1 lead will connect to the bottom conductor in slot *34*.

(22) According to *Rule 8*, the R_2 lead will fall one front pitch measured in a counter-clockwise direction from the first reversing jumper; that is, the R_2 lead will fall in $34 - 12 =$ slot *22*. It will connect to a bottom conductor in slot *22*.

(23) In a manner similar to item 21, R_3 is found to fall in $17 - 15 =$slot *2*.

(24) In a manner similar to item 22, R_4 is found to fall in $50 - 12 =$ slot *38*.

(25) R_5 will fall in $33 - 15 =$ slot *18*.

(26) R_6 will fall in $18 - 12 =$ slot *6*

Items 21 to 26 are given in the third line, eleventh column of Table VI.

(27) According to *Rule 13* and since there are three short-pitch connections per section, the first group of short-pitch connections will connect the top conductors in slots *48*, *47* and *46* with the bottom conductors in slots that are a distance of one short pitch measured in a counter-clockwise direction from the above slots; that is, in slots, *37*, *36* and *35* respectively.

(28) In a similar manner the short-pitch connections for the second section of the A phase will be found to connect the top conductors in slots *36*, *35* and *34* with the bottom conductors in slots *25*, *24* and *23* respectively.

(29) Likewise, the short-pitch connections for the first section of the B phase will be found to lie adjacent to

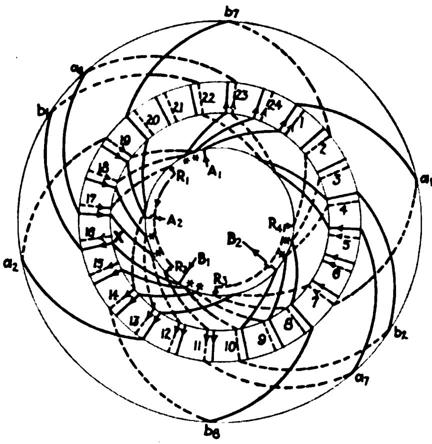


Fig. 1—Method of locating the short-pitch connections.

This winding is wound left-hand for a four-pole, two-phase machine. It will be noticed that the short-pitch connections (marked with asterisk) start from slots adjacent to and in a counter-clockwise direction from the slots to which the line leads connect. For example the short-pitch connections for the first section of the A phase start from slots *24* and *23*, which are adjacent to and in a counter-clockwise direction from slot *1*, to which the A_1 lead connects.

the B_1 lead; that is, the short-pitch connections will connect the top conductors in slots *16*, *15* and *14* with the bottom conductors in slots *5*, *4* and *3* respectively.

(30) In a similar manner, the short-pitch connections for the second section of the B phase will be found to lie adjacent to the B_2 lead; that is, the short-pitch connections will connect the top conductors in slots *4*, *3* and *2* with the bottom conductors in slots *41*, *40* and *39* respectively.

(31) The short-pitch connections for the first section of the C phase will lie adjacent to the C_1 lead; that is, the short-pitch connections will connect the top conductors in slots *32*, *31* and *30* with the bottom conductors in slots *21*, *20* and *19* respectively.

(32) The short-pitch connections for the second section of the C phase will fall adjacent to the C_2 lead; that is, the short-pitch connections will connect the top conductors in slots *20*, *19* and *18* with the bottom conductors in slots *9*, *8* and *7* respectively. The data given in items 27 to 32 inclusive is given in the twelfth column, third line of Table VI.

The rules and explanations that have been given in the preceding pages will enable the winder to lay out any wave winding either right- or left-hand wound, and having the leads connected to top or to bottom conductors. It will pay the winder to construct a few diagrams in the manner that has been shown until the different points peculiar to this type of winding are thoroughly mastered. The same procedure is followed in connecting a winding as is used in constructing the diagram and after the rules are once learned it is a simple matter to calculate the data or check a winding.

In the concluding article of this series will be given tables and data for use on wave windings for rotor and for stator windings having 120-deg. spacing between the line leads. Methods of laying out and determining the overlapping phase belts in windings where the number of slots is not a multiple of the number of poles will also be discussed.

Ways of Obtaining Variable Speeds

(Continued from page 524)

them in order to get the speed change. Their advantage lies in the fact that the change can be quickly made by merely shifting one of the pulleys across the face of the other. On the other hand, the friction surface wears rapidly and requires frequent renewal or maintenance. This is due to the fact that the parts of the faces of the two pulleys in contact with each other do not travel at the same rate of speed.

No effort will be made here to describe any of the various, special mechanical devices consisting of sliding arms or links which may be shifted and thus vary the speed, that have been brought out. Many of these have been impractical "freaks" that did not get beyond the model stage or the patent office. In some types, which would operate, the wear is too great or other practical features are lacking which prevent them having extended use.

In conclusion it may be well to point out that almost all machines have a one best speed for each kind or class of work. Also that in some cases this best speed will vary from day to day, due to climatic conditions. With provision for obtaining a variable speed the best and most effective operating speed can be obtained for each condition.

Editor's Note: Acknowledgment is made to the following companies for assistance in furnishing information and photographs for this article: Lewellen Mfg. Co., Columbus, Ind.; The Moore & White Co., Philadelphia, Pa.; The Oilgear Co., Milwaukee, Wis.; Reeves Pulley Co., Columbus, Ind.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Cooper-Hewitt Electric Company, 95 River Street, Hoboken, N. J.—A 32-page booklet entitled "Work-Light" gives in a slightly technical manner an interesting discussion of the relation between work and illumination. Among the subjects discussed are: Adapting light to a purpose; why Cooper-Hewitt is work light; work-light and its work; the economy of work-light; planning a work-light installation; the maintenance of work-light; the service behind work-light.

The Safety Equipment Service Company, 1104 Hamilton Avenue, Cleveland, Ohio.—A booklet describes the Electro safety punch press guard. This affords protection to workers by requiring each of the one or more operators to press two push buttons simultaneously in order to trip the press and so assures that all have their hands out of danger. The booklet shows numerous illustrations of installations and also gives an installation wiring diagram.

The Martindale Electric Company, 11709 Detroit Avenue, Cleveland, Ohio—Bulletin describes the Imperial Blow-er Clean which operates either as a portable suction cleaner or blower for removing dust and other accumulations from machinery, particularly electrical installations.

Buffalo Pulley and Caster Company, Inc., Buffalo, N. Y.—A folder describes Belt-Grip leather pulleys which are made of solid leather discs and so give a leather-to-leather contact.

Allan Manufacturing and Welding Company, Inc., Buffalo, N. Y.—A folder describes the Almanac electric welding and cutting equipment and accessories, such as electrodes and holders, shields and helmets.

The Industrial Electric Company, 5230 St. Clair Avenue, Cleveland, Ohio—A folder describes the Indian constant potential charging plant which is a motor-generator set with indicating and control apparatus, built to charge any sizes of batteries in one day. When being charged with this outfit, batteries are connected in multiple instead of in series.

Armature Coil Equipment Company, 2415 Forestdale Avenue, Cleveland, Ohio—A folder describes the insulated or bare strap copper bar bender which is made in two sizes. The smaller size takes stock ½ in. to ¾ in. width and the larger machine handles bars 1 in. thick to 1¼ in. wide, without damaging insulation.

Whiting Corporation, Harvey, Ill.—Type C electric solenoid brake, which is a quick-acting, powerful brake designed especially for crane service, is described in a special folder. This also includes the description of a foot brake.

G. M. Bartlett, 2533 College Avenue, Indianapolis, Ind.—A folder describes the Bartlett angular transmission for transmitting power between two shaft ends at a uniform angular velocity ratio of 1 to 1 with shaft angular displacement of 90 deg. or more. This can also be used with parallel offset shafts. Power is transmitted through a joint somewhat similar to a special universal coupling.

W. A. Jones Foundry and Machine Company, 4401-4451 West Roosevelt Road, Chicago, Ill.—Catalog 29 devotes 250 pages to a discussion, description and prices of Jones spur, bevel, mitre, worm and spiral gears with either cut or moulded teeth and spur and worm gear speed reducers. In addition there are several pages of general engineering data.

The North American Manufacturing Company, Cleveland, Ohio—A folder describes the North American gas-electric portable blow torch and some of its various applications. This consists of a small electric blower to furnish an air blast in the gas mixture and will develop temperatures from 500 deg. F. to 2,500 deg. F.

Pyott Foundry Company, 328 North Sangamon Street, Chicago, Ill.—Catalog 28 describes in 160 pages the line of cast-iron pulleys, sheaves, sprocket wheels, molded-tooth gears, power transmission machinery and special gray-iron and semi-steel castings.

Mutual Electric and Machine Company, Detroit, Mich.—A folder describes the Bull Dog "Luminized" safety switch which has a permanent, lustrous, aluminum finish on the switch box and is not only more visible in the dark through the reflection of light on its surface but also has a surface which is claimed to resist rust, acids and alkalies and to be easier to keep clean.

Morse Chain Company, Ithaca, N. Y.—Publication 24 entitled "Large Power Drives" illustrates a number of applications of Morse silent chains of 100 to 5,000 hp. rating.

Fairbanks-Morse and Company, Chicago, Ill.—Bulletin H-288 entitled, "Ball-Bearing Motors for the Textile Industry," not only gives the construction and operation, but the advantages obtained from ball-bearing motors, particularly in textile mills. This description includes the Type T motors for individual drives of looms and similar machines, Type H motors for two- and four-frame drive and Type EH enclosed and ventilating motors for opener and picker-room drives and similar installations.

Reed Air Filter Company, Inc., Louisville, Ky.—Bulletin 106 describes the Reed system of air filtration, which consists of drawing the air through a cell consisting of closely interlocked filtering media covered with a viscous, adhesive coating upon which dust and dirt are deposited. The cells may be removed and cleaned. Other bulletins discuss tests, specifications and data, and the use of Reed air filters for general ventilation, for ventilation of electrical equipment, for air compressors, internal combustion engines and pneumatic equipment and for drying operations and bacterial control.

American Chemical and Engineering Company, 546 West Washington Street, Chicago, Ill.—A folder describes "Full Speed" pulley covering which consists of a fabric saturated with the compound and applied to the face of the pulley. This becomes hard and firm, is water-, oil-, acid- and fire-proof, and increases the friction hold of the belt on the pulley.

The Keystone Lubricating Company, Philadelphia, Pa.—A booklet entitled, "Send Him Back to Them—Safe," discusses the advantages of the Keystone manifold safety system of grease lubrication from a safety, fire prevention and industrial operation standpoint.

The New Departure Manufacturing Company, Bristol, Conn.—A folder entitled, "What New Departure Ball Bearings Mean in Your Electric Motor," lists some of the advantages which it is claimed result from the use of ball bearings in electric motors.

Dodge Manufacturing Corporation, Mishawaka, Ind.—Folders describe the new Dodge-Timken roller hanger bearing and show cutaway as well as sectional views of it. Dimensions and prices are also given.

Baker R. & L. Company, Industrial Division, Cleveland, Ohio—Catalog 24 on "Industrial Tractors and Trucks" devotes fifty-two pages to illustrating, describing and giving the specifications of the different types of industrial trucks and tractors, together with a wide line of industrial applications.

Anaconda Copper Mining Company

(Continued from page 511)

also in radio sets, in telegraph, telephone and in cable, in the piano, the talking machine, the automobile and in water service as plumbing pipe. They serve in over 50,000 different shapes, each rust-free and practically everlasting.

In the United States there is now a per capita consumption of almost 15 lb. of copper compared with 3.1 lb. for Europe.

The constantly growing demand by the public for better qualities and longer life in metal articles, the rapidly growing tendency to use more electrical energy, and other developments in science and industry indicate a steady growth in the demand for copper, not only in the United States but throughout the world.

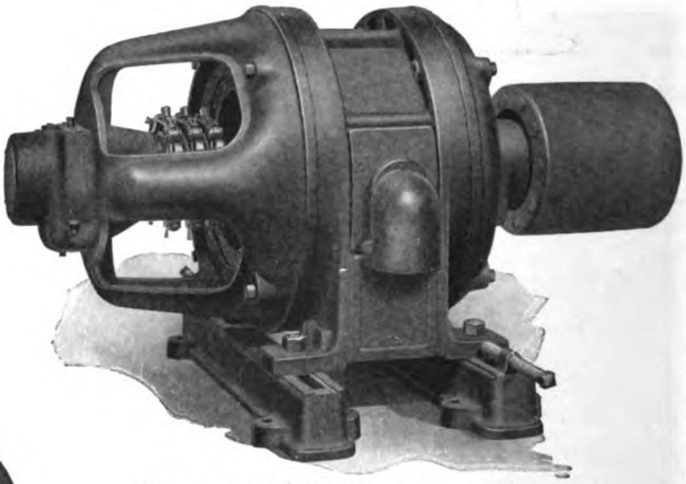
ounded 1882 as Electrical Review DECEMBER, 1924 McGraw-Hill Co., Inc., Chicago, Ill.

Industrial Engineer

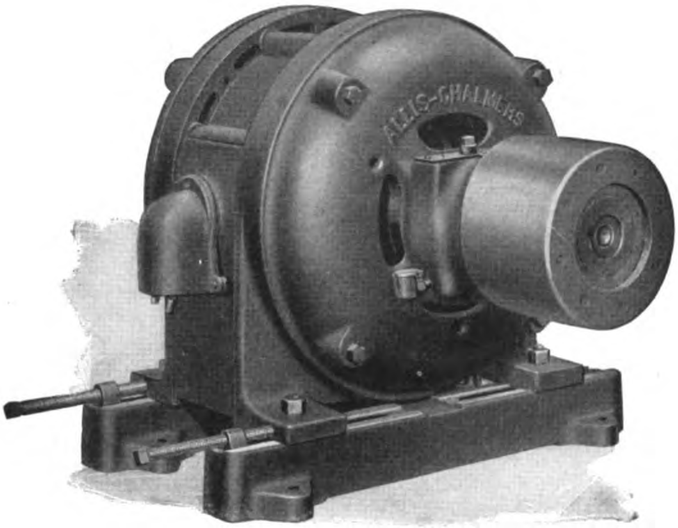
Devoted to the
aintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

ALLIS-CHALMERS

Polyphase Induction Motors



Type "ARY" Slip Ring Motor



Type "AR" Squirrel Cage Motor

Constant and Variable Speed

60 and 25 Cycle

Type "AR" and "ARY" motors are designed with exceeding ruggedness, cast steel in place of cast iron being a prominent feature.

They are of the riveted steel frame type. The stator end frames and feet are integral and are made from electric steel castings, insuring a very rigid construction and eliminating any possibility of broken feet.

The method of ventilation is very effective, resulting in even cooling and avoiding of "hot spots."

Shafts are very rigid and stiff, while bearings are of liberal design with spacious oil wells.

Insulation is of highest grade, stator being treated with baked-on insulating varnish, making the whole structure dust and moisture proof.

PRODUCTS:

Electrical Machinery
Gas Engines
Steam Engines
Steam Turbines
Condensers
Oil Engines
Hydraulic Turbines
Pumping Engines
Centrifugal Pumps
Mining Machinery
Metallurgical Machinery
Crushing Machinery
Cement Machinery
Flour Mill Machinery
Saw Mill Machinery
Air Compressors
Air Brakes
Steam and Electric Hoists
Farm Tractors
Power Transmission Machinery

ALLIS-CHALMERS MANUFACTURING CO.

MILWAUKEE, WIS. U.S.A.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Volume 82 Chicago, December, 1924 *Number 12*

Another Example of Poor Wiring

Where It Would Not Be Expected and Will Sometime Prove Very Expensive

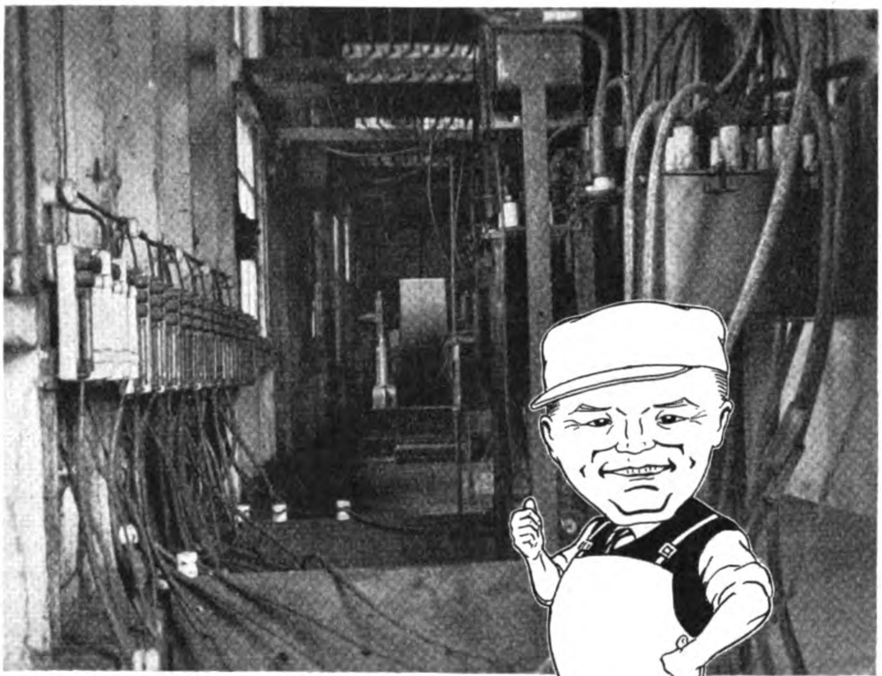
UNDER date of October 22 I received the following letter and photo from E. S. Lincoln, a consulting electrical engineer at Portland, Maine. It was evidently called forth by the comment on page 461 of the October issue dealing with the wiring about transformers at the point where electrical service is brought into an industrial plant.

I have noticed from time to time in INDUSTRIAL ENGINEER a number of photographs exposing some undesirable wiring in the industrial plant.

I am enclosing herewith a photograph taken in a central station which shows some pretty poor wiring for 2,300-volt service. I can readily see how some industrial plants would slip up, since electric service is only one of their many troubles, but the central station has little excuse, as it is their main line of business. It is certainly surprising to see what some of these operating companies will do in the way of construction.

In the last few years, however, there has been a decided change for the better and practically all of the large companies and a number of the smaller ones are bettering conditions every day. On the other hand, it would do some central station men good to visit some of their industrial customers and get a few pointers on first-class wiring.

I am particularly glad that Mr. Lincoln has selected this horrible example of poor wiring from a central station installation for it goes to show that industrial men are not the only ones guilty of patching up a job that was already a mess before the patching operation began. I agree with Mr. Lincoln that in some cases there may be some justification for the existence of these eyesores of wiring in industrial plants where the man responsible for installation work has a hundred and one things to do, with only one head and one pair of hands and not enough hours in the day to get to all the things he would like to do. But when this is the case the opportunity presents itself to show the boss the need for more help and the actual loss through accidents and lost time in production by allowing patched-up and temporary work to become permanent, by reason of the fact that nothing has happened. When the thing does happen that is expected, and time and natural wear and tear will certainly collect their due, the old saying about spilt milk will not only be true but prove that procrastination is the most reliable thief of good intentions that the world has ever known. And, too, no one ever gets much sympathy for excuses; it's the fellow with less ability, perhaps, but with the "do-it-now" spirit who is considered the smart fellow and gets the raises.



But don't overlook the last sentence of Mr. Lincoln's letter. There he gives to the devil and his hindermost followers the credit that is due them. Some of the best wiring I have ever seen, best because it shows care in layout and workmanship, has been in industrial plants and I had something to say about these in the articles on "Where Wiring Can Be Improved Around Machines," in the May and June issues.

We would like to show up more of the good wiring jobs that you men are proud of; so if you have an installation that you believe is up to date in particular respects, let us say something about it in INDUSTRIAL ENGINEER.

Practical Pete

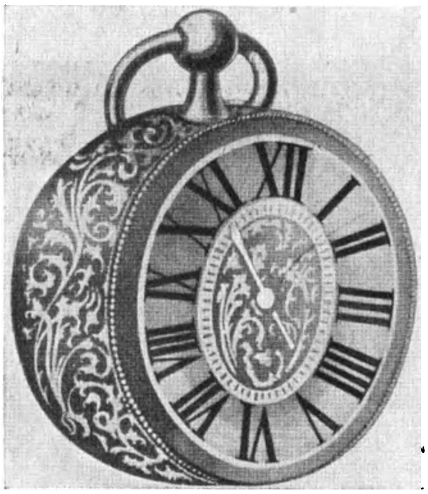
A Glimpse Into the Works of the

Elgin National Watch Company

Where by careful and accurate machine and hand-work gold, silver, platinum, steel, and brass are turned into high-grade watches, and every part, even to the smallest screw, is made interchangeable

PROBABLY few industries call for more perfect lighting than watch-making; also few require such a combination of careful and accurate machine- and handwork on small pieces. Standard-size watch movements contain about 211 separate pieces, about a third of which are screws, assembled together between plates. The movements vary in size from the smallest ladies' wrist watches about 0.7 inch in diameter to the 18-size man's watch, which is about 1.766 inches in diameter.

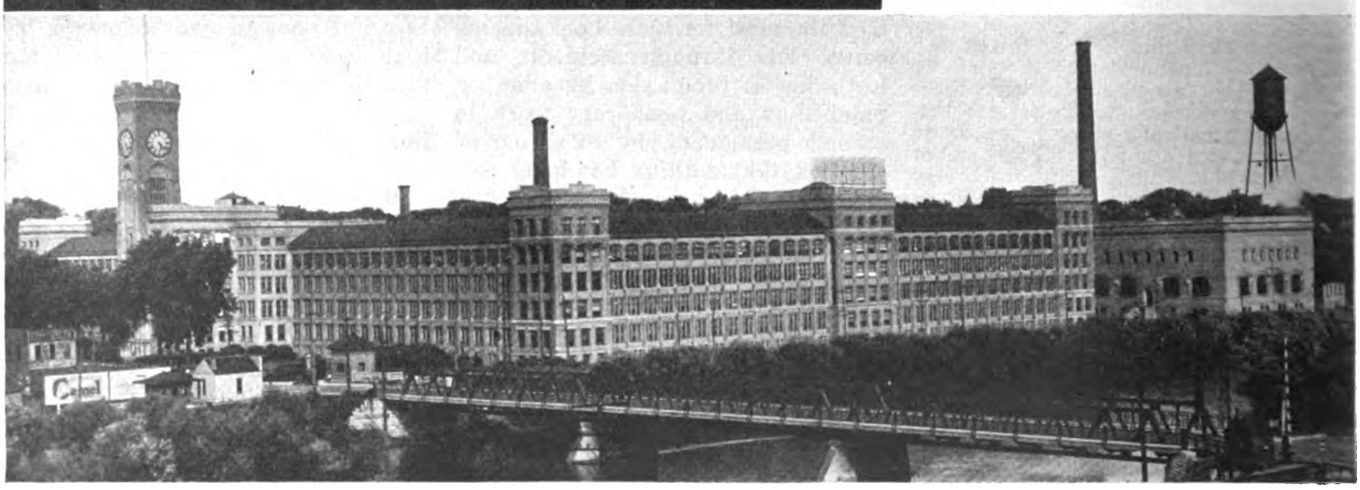
Watches today are vastly different from the early watches made about four hundred years ago, which were about the size of a large alarm clock. The first watch was made entirely of iron, in 1504, and was about 6 in. in height. It had only one hand and lost about an hour a day. Many of the principles of the first watches and clocks, with refinements and improvements, however, are still incorporated in modern time-pieces. These are, for example, the time train, the balance wheel and for clocks, the pendulum. Much of the improvement has been in the escapement, which controls the action of the clock or watch to make it keep accurate time.



The first watch, made in 1504.

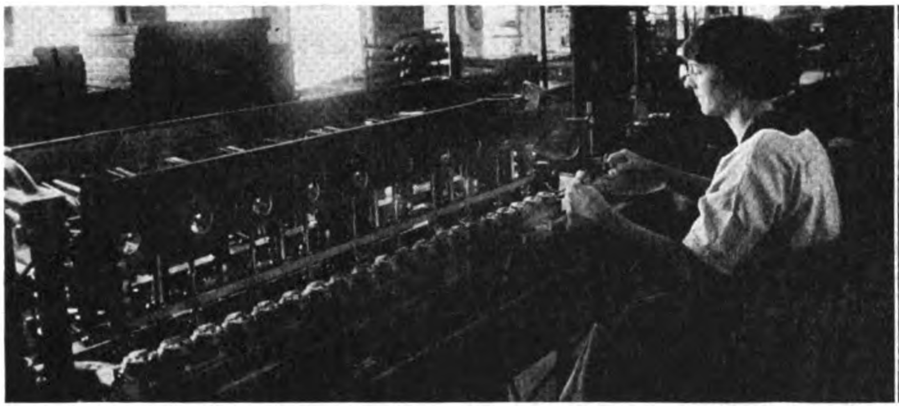
Peter Henlein, a young locksmith of Nuremburg, Germany, is credited with making the first so-called watch. This was spring-driven, about 6 in. in diameter, was made entirely of iron and lost about an hour a day.

The accuracy with which a watch must operate if it is to keep time is shown by the fact that the balance wheel must vibrate exactly five times a second or 18,000 times an hour. One more or less vibration an hour will make the watch run 4.8 seconds fast or slow a day, or 2.4 minutes a month. Much greater accuracy is expected from even moderate-priced watches and is required in watches used to control the operation of trains.



The Elgin, Ill., factory of the Elgin National Watch Co., and its observatory.

Two astronomers are in charge of the Elgin observatory where time is taken from the stars. This is used to check the timing of special, precision clocks enclosed in hermetically-sealed glass jars. These clocks are the standard for timing Elgin watches. The Elgin factory consists of a group of buildings in the form of a large quadrangle. They are narrow with windows on both sides extending to the high ceilings, to give as much natural light as possible. Much of the handwork in a watch is performed under the magnifying glass; so lighting is an important consideration.



Watch and clock making requires a comparatively small amount of power as it is light manufacturing and much of it is hand-work. It does, however, require a degree of care and skill much greater than is ordinarily required in most industries.

One of the pioneers and leaders of the development of the watch and clock industry in the United States is the Elgin National Watch Company, Elgin, Ill. This was started in 1864 under the name of the National Watch Company by B. W. Raymond, a pioneer in mid-western industrial enterprises. The company is now under the administration of its fourth president since its organization. Today it is producing about 1,000,000 watches annually. The present plant, shown in an accompanying illustration, employs about 3,500 to 4,000 men and women.

Watch-making was originally a hand process. The first successful attempt to make it a machine process was in 1840. Since then many improvements have been made in the manufacture of watches and now all parts are made by machinery. This permits of standardized manufacture and interchangeability of parts in practically all American watches. A repair part that will fit can be purchased almost anywhere in the world and inserted by a competent watch repairer.

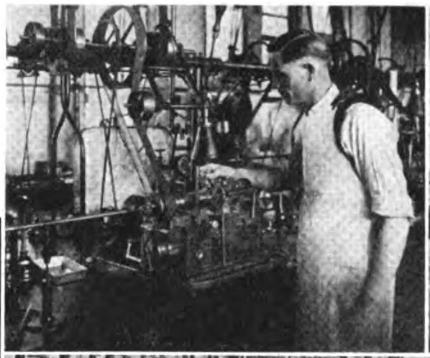
There are 3,773 separate operations in making a 23-jewel Elgin watch. (*Continued on page 604*)

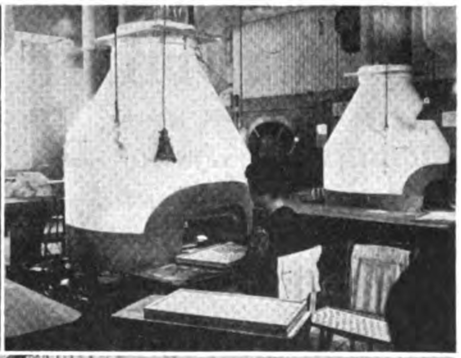
Two steps in watchmaking—ornamenting the plates and (right) drawing hairsprings.

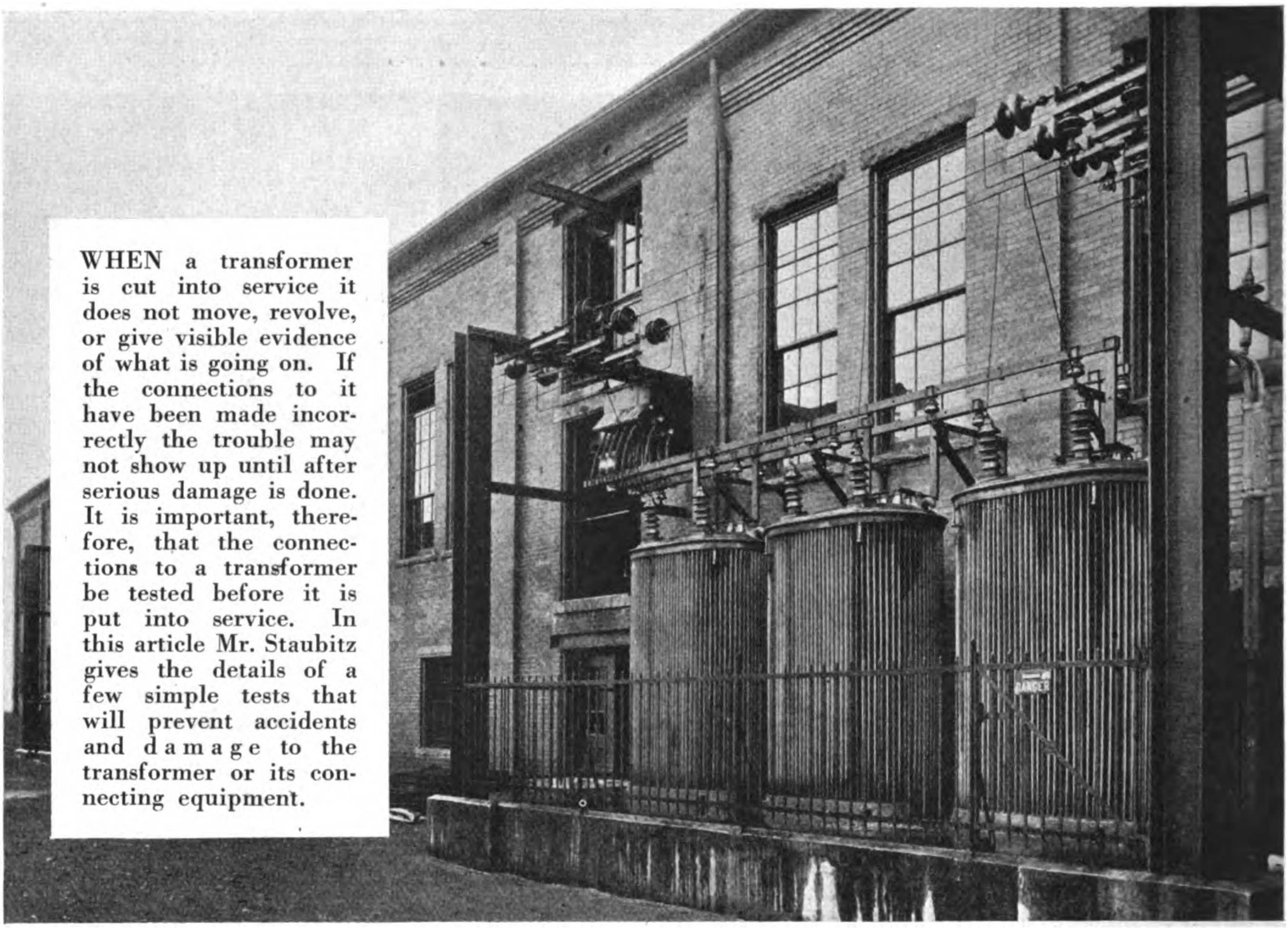
The machine above ornaments ten watch plates at a time, with geometric scroll work. It operates on the pantagraph principle and reproduces the movements of an electric stylus over a pattern or master plate. The various holes on the watch plate are represented by insulated inserts on the master plate. When the electric stylus touches these inserts the cutting tools are automatically lifted from all ten watch plates to avoid damaging these points. The earliest watches did not have a hairspring. Later pig bristles were used. In modern watches the accuracy is controlled by the hairspring and balance wheel. These springs are drawn through a diamond die (right) which will draw 100 miles of hairspring wire before wearing out. The best steel dies will draw only 8 miles.

Some of the special machines required in watchmaking.

When watchmaking became a manufacturing process instead of handwork it became possible to standardize the parts and make them interchangeable. To do this economically has required the invention of many special machines. One of these, the automatic pinion turning machine, is shown below. Another, the automatic jewel setting machine (center) not only makes the setting but sets sixteen jewels a minute. Jewels, made from ruby or garnet, form the more important watch bearings. Standard watches are made with seven to twenty-three jewels. One drop of oil a year properly applied, lubricates a watch. Dial making (right) is another interesting process. The operator feeds the dials into the front of the furnace and they drop out the back when finished. The numerals are then printed on and baked in. After the different parts of a watch are assembled, with the exception of balance, dial and hands, they go to the finishing room (lower right). Here expert craftsmen inspect the work and finish the assembly. The movement is then tested and adjusted and is ready for use when inserted in a case.







WHEN a transformer is cut into service it does not move, revolve, or give visible evidence of what is going on. If the connections to it have been made incorrectly the trouble may not show up until after serious damage is done. It is important, therefore, that the connections to a transformer be tested before it is put into service. In this article Mr. Staubitz gives the details of a few simple tests that will prevent accidents and damage to the transformer or its connecting equipment.

Here is a standard industrial type of transformer installation used by one large company. This bank of transformers is delta connected on both the high- and low-tension sides. In this article are given several precautions that must be observed before such a bank is thrown into service for the first time.

Practical Tests That You Can Use In

Checking and Testing Transformer Connections

Including Ways of Determining Ratio, Polarity and Impedance and Things to Be Done Before Connecting or Paralleling Single-Phase or Three-Phase Banks of Transformers

By L. P. STAUBITZ
Chief Electrician, Laclede Steel Company, Alton, Illinois

MANY interesting and practical problems are met in the operation of both single-phase and polyphase transformers. A transformer is usually thought of as being such a simple piece of apparatus that in many cases it is often considered unnecessary to make any tests before placing it in operation. However, a few carefully-made tests taken at the time of installation are good insurance against accidents or damage to the transformer and will greatly assist in making connections and solving any trouble that may arise.

If a transformer is to be operated entirely alone on both the primary and secondary sides, practically the only tests needed would be the regular insulation test, test of transformer oil, and possibly a voltage-regulation test. If the transformer were installed on a public utility system the public service company would, no doubt, complete the other usual tests including magnetizing loss, which represents the amount of energy required to keep the transformer alive without any secondary load.

Where transformers are to be operated in parallel with others, a knowledge of the characteristics of the transformer, gained from tests, is of great value.

If two transformers are to be operated in parallel it is necessary that they should both have the same polarity; otherwise one transformer will short circuit the other with disastrous results. One way of testing for polarity—this method is often used but is not to be recommended—is to connect the new transformer to the bus on the low-voltage side and cut in the high-tension winding through a fuse. The lineman can judge from the manner in which the fuse is blown whether or not the transformer is of the cor-

rect polarity. Usually the polarity is known from the make of the transformer, thus aiding the test.

A better test can be made in the following manner: At any place where there is an alternating-current supply of the same frequency as the transformer under test, connect the high- and low-tension windings, as shown in Fig. 1, by an insulated wire so that the high-tension lead on one side of the transformer is tied to the low-tension lead on the same side of the case. Have all leads free from ground and not touching. Now apply a voltage of 110 or 220 volts to the high-tension winding. Be sure to apply this voltage to the proper winding. Then connect a voltmeter, having a full-scale reading approximately fifty volts higher than the voltage of the test line, across the unconnected high-tension and low-tension leads as shown in Fig. 1. If the voltmeter reading is less than the voltage of the test circuit the instantaneous polarity is as shown by the arrows in Fig. 1 and the transformer is said to have subtractive polarity. The subtractive action is caused by the voltage induced in the low-tension winding opposing the current trying to flow through the voltmeter from the two high-tension leads. If the voltmeter reading is higher than the line voltage, the polarity is as shown in Fig. 2 and the transformer is said to have additive polarity. This is due to the fact that the induced voltage in the low-tension winding aids the voltmeter current. Unless the line voltage used for testing is very steady, it is usually best to perform this test with two voltmeters, using one as shown in Fig. 1 and connecting the other across the source of power supply.

Another way of testing the polarity of a transformer is to use a small storage battery and a millivoltmeter of 500-millivolts range. Connect the storage battery to the high-tension winding of the transformer as is shown in Fig. 3. The millivoltmeter should be connected as shown in Fig. 3, with its positive terminal connected to the low-tension lead that is on the same side of the transformer as is the high-tension lead that is connected to the positive side of the storage battery. The high-tension side should be connected through a switch to the storage battery. On closing the switch the millivoltmeter will give a small deflection. If the needle is thrown up scale then the current flow and polarity of the two windings are as shown in Fig. 3; that is, the transformer will have additive polarity.

The flow of current in the primary winding is determined from the polarity of the battery and is as shown by the arrow. The flow in the secondary must be as shown by the other arrow if the millivoltmeter reads up. This then means that when current is entering the primary through the left-hand lead, it is leaving the secondary over the left-hand secondary lead at the same instant.

Great care must be used to see that the millivoltmeter is disconnected from the secondary winding before the battery switch is opened, as it would be ruined by the back-kick from the winding. The switch should be opened as soon as possible in order not to allow the current to build up to any higher value than

Figs. 1 to 6—Methods of testing for polarity and how to parallel transformers of opposite polarity. In Fig. 1 two adjacent high- and low-tension terminals, H_1 and X_1 are connected together and a voltmeter is connected to the other two adjacent terminals, H_2 and X_2. The 220-volt alternating-current power is applied to the high-tension winding as shown. If the voltage measured on the voltmeter is less than the voltage applied to the high-tension winding the transformer has subtractive polarity, as shown in Fig. 1. If the voltage reading is greater than the supply voltage, the transformer has additive polarity, as shown in Fig. 2. In Fig. 3 is shown another method of testing for polarity by using a storage battery and a direct-current millivoltmeter. In paralleling two single-phase transformers the connections should be made as shown in Fig. 4. If the voltmeter reads zero the voltmeter may be removed and the connection completed. Figs. 5 and 6 show the connections for paralleling two single-phase transformers having the same polarity and also the connections for paralleling them if they have opposite polarities.

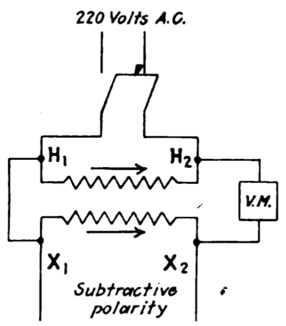


FIG. 1

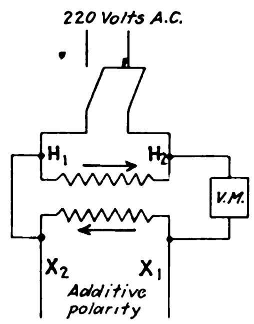


FIG. 2

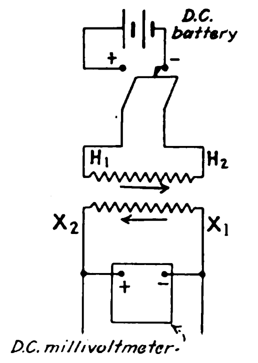


FIG. 3

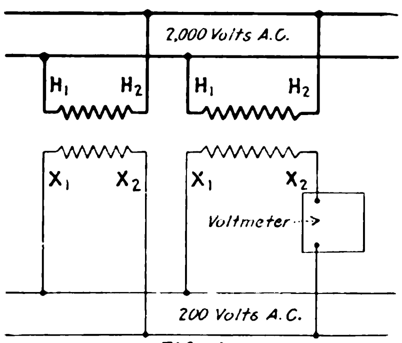


FIG. 4

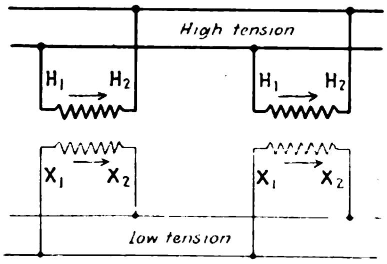


FIG. 5

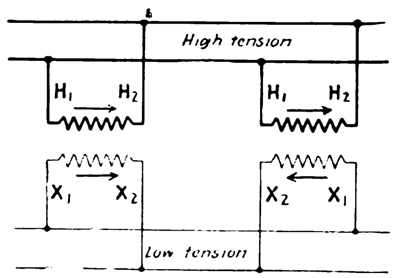


FIG. 6

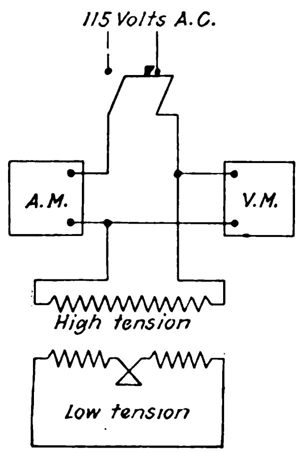


FIG. 7

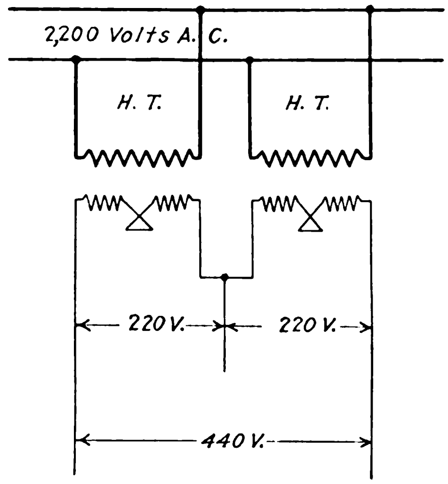


FIG. 8

Figs. 7 and 8—Method of measuring impedance of transformers.

In Fig. 7 the impedance of the transformer is being measured by shorting the low-tension winding and applying 115 volts alternating current to the high-tension winding, at the same time measuring the current and voltage impressed on the high-tension winding. The voltage divided by the current gives the ohms impedance. Fig. 8 shows an arrangement for connecting two transformers to obtain twice the secondary voltage that would be obtained if the secondary windings were connected in parallel.

necessary as the switch will draw an arc on being opened.

Value of Making Ratio Test on Transformers

The ratio test is of value in determining whether the various taps are properly made. Where transformers are to be operated in parallel it is well to make a check on the voltage ratio.

A simple way to do this if a low reading, alternating-current voltmeter is available, is to excite the high-tension winding from a 440-, 220-, or 110-volt power source of the same frequency as the transformer and obtain simultaneous readings of the voltmeters across the primary and secondary windings. The ratio of the voltmeter readings is then the ratio of transformation of the transformer.

If a low-reading voltmeter is not available this test may be made as in Fig. 2 and the difference between the readings is the voltage produced by the secondary winding. Then the ratio of the reading of the line voltmeter to the difference of the two meters represents the transformation ratio.

How to Measure the Impedance of a Transformer

The relative impedances of two transformers have a great deal to do with their successful operation in parallel. The impedance voltage of a transformer is the voltage required to cause full-load current to flow in one winding of a transformer with the other winding short circuited. The low-tension winding is usually short circuited and the voltage measured on the high-tension side. While the impedance is determined by the voltage required to force full-load current through the transformer with the low-tension winding shorted, it is usually expressed as a percentage of the normal, high-tension voltage.

If the impedance of a transformer is unknown the following test will determine it. The secondary leads of the transformer are bolted together, making a good electrical connection. An ammeter is placed in series with the high-tension winding and a voltmeter is connected in as shown in Fig. 7. The range of the ammeter will depend upon the impedance ohms of the transformers; for the smaller transformers, a meter of one or two amperes range will be sufficient when testing with 115-volt power supply of the same frequency as the transformer. Power is applied to the arrangement shown in Fig. 7 and simultaneous readings are taken of the ammeter and voltmeter.

Assume that the transformer under test is rated at 75 kva., 12,000/440 volts, 60 cycles, 6.5 amp., full-load current. On making the test shown in Fig. 7, the readings of the meters were 115 volts and 1 amp. Then, impedance volts = (full-load current $\times$ volts read) $\div$ current read = $(6.5 \times 115) \div 1 = 718.75$.

The impedance, however, is usually expressed as a percentage of the normal high-tension voltage; hence the per cent impedance equals $(718.75 \div 12{,}000) \times 100 = 5.99$ per cent.

Fig. 9—Here is a mistake frequently made in connecting an open-delta bank.

In the diagram on the right, the right-hand transformer is of opposite polarity to the other transformer in the bank. In consequence 189 volts is obtained across X_1 and X_3 instead of 110 volts. The remedy is to reverse the leads X_3 and X_4.

Effect of Characteristics on Parallel Operation

The two chief characteristics affecting parallel operation are voltage ratio and impedance. It is, of course, necessary to have correct polarity of the two transformers before any attempt at parallel operation is made.

If two transformers having the same impedance, but slightly different secondary voltages are paralleled, heavy circulating currents will flow between the two transformer secondaries even under no-load conditions. The value of this cross or

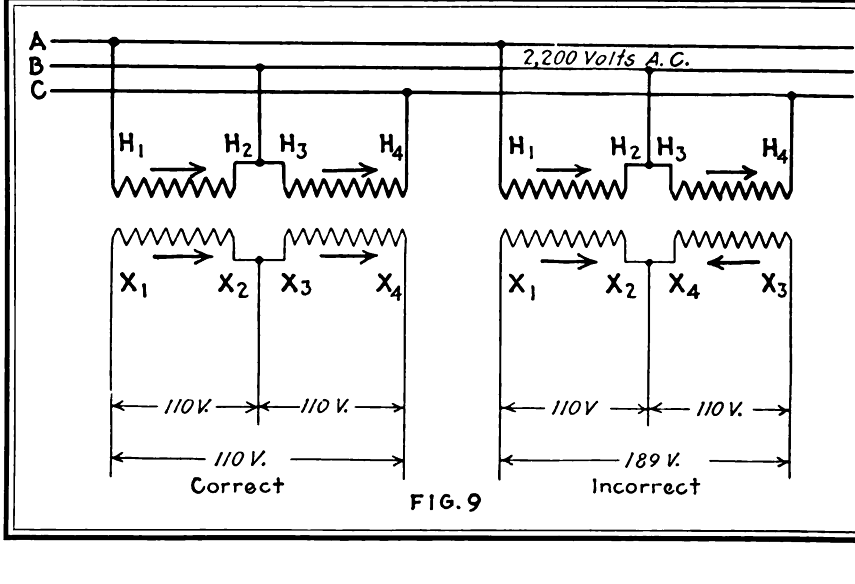


FIG. 9

circulating current may be determined from the following formula: Per cent full-load current = difference in secondary voltage × 100 ÷ sum of impedance volts of each winding.

The impedance volts is the voltage required to force full-load current through the high-tension winding when the secondary winding is short circuited. The voltage difference and impedance voltage used in the above formula must all be referred to the same winding.

In Fig. 4 let us assume that each transformer is rated at 200 kva., 2000/200 volts, impedance of each transformer equals 10.5 volts referred to secondary winding or 5.25 per cent. With the transformers connected as shown, assume that the voltmeter reads 21 volts, indicating that there is a difference of 21 volts between the secondaries of the two transformers. Substituting in the formula given we find that the per cent of full-load current that will circulate between the two transformers equals $(21 \times 100) \div (10.5 + 10.5) = 100$ per cent. Consequently the transformers would overheat badly if an external load equal to their rating were applied.

Fig. 4 shows the manner in which the secondary voltage should be tested before paralleling. The voltmeter should read zero in order to obtain the best operating conditions. The voltmeter used should be of double the range of the voltage of one transformer, for if the polarities of the windings are not alike the voltage will be double the rating of the one transformer. This test indicates the polarity as well as the voltage difference of the two secondary windings of the transformers tested.

Figs. 10 to 13—Methods of testing connections of three single-phase transformers which are to be connected to form a bank.

In Fig. 10 the transformers are connected delta delta. In testing, the high-tension connections are completed as shown and the low-tension connection between X_2 and X_3 is made. For the arrangement to be correct, a voltmeter connected across X_1 and X_4 should show the same voltage as across the low-tension winding of one transformer. The connection between X_4 and X_5 is then made and if the voltmeter, connected as shown in the diagram, reads zero, the connections are correct. At the left is shown the relation between the voltages of the transformer bank. Fig. 11 shows the same connection as Fig. 10 but the transformers have the opposite polarity as is shown by the marking of the transformer leads and by the voltage diagram shown at the right. In making a delta-delta connection it is possible to make an error in connecting the transformers and thus have one transformer with reversed polarity. This is shown in Fig. 13. In Fig. 12 is shown a star-star connection. In testing, the high-tension connections should all be made as shown and the low-tension connection between X_1 and X_3 should be completed. For the connection to be correct, the voltage across X_2 and X_4 should be 1.73 times the low-tension voltage of one transformer, that is, across X_3 and X_4. X_3 is then connected to X_5 and the test repeated.

An ammeter or a current transformer and ammeter may be inserted in the leads to determine any circulating current at no load. It is always best to measure the load on two transformers placed in parallel to be sure that each is carrying its proper load. An open fuse or loose connection in one transformer might throw all the load on the other.

If two transformers of the same rating have the same secondary voltage but do not have the same percent impedance, they will not divide their loads properly. A 1,500-kva. transformer of 2.5 per cent impedance was to operate in parallel with a 3,000-kva. transformer of 5 per cent impedance. In order to prevent the smaller transformer from overheating due to carrying too heavy a load, because of the difference in impedance, it was necessary to insert reactors in series with the 1,500-kva. transformer so that its total impedance equalled 5 per cent. The load division then was in proportion to the transformer ratings.

If the impedance difference is not too great, it may be compensated for by a change in the voltage taps. The transformer having the lower impedance should have a lower secondary voltage.

From the foregoing it is seen that

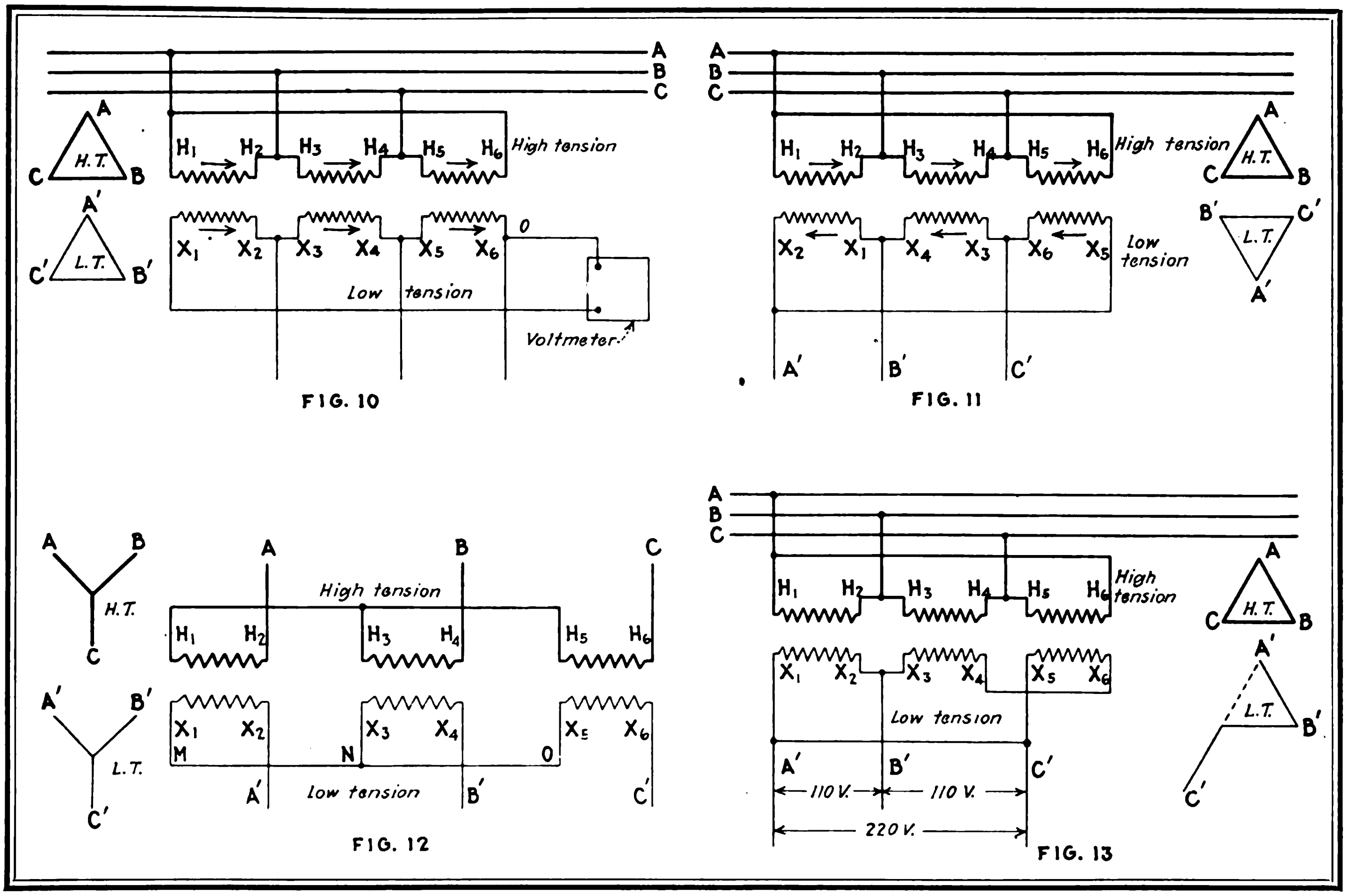


FIG. 10 FIG. 11 FIG. 12 FIG. 13

in order to parallel two transformers it is necessary that the polarity be correct, that the voltage ratio be the same, and that the per cent impedance of the transformers be equal.

Transformer Connections for Single-Phase Service

Single-phase transformers may be connected for single-phase transformation or in banks for three-phase operation. Many interesting combinations of connections may be obtained with both single-phase and polyphase connections.

Fig. 5 shows two single-phase transformers of the same polarity correctly connected in parallel. Fig. 6 shows two single-phase transformers of different polarity connected in parallel.

A connection which is often of service is shown in Fig. 8. With this arrangement are used two transformers having their primaries connected in parallel and their secondaries connected in series. By this arrangement twice the secondary voltage is secured that would be obtained if the secondary windings were connected in parallel as usual. In this manner, 440 volts may be obtained in an emergency when only 220-volt transformers are at hand. By using different-ratio transformers with this connection other voltages can be obtained. It makes a very good emergency connection. The load carried by the combination would be limited to the current-carrying capacity of the secondary winding of one transformer. If the transformers are of different sizes the load should, of course, be limited to the carrying capacity of the smaller transformer.

Transformer Connections for Three-Phase Service

In connecting single-phase transformers in banks for polyphase operation, it is necessary to consider the characteristics of the various transformers.

The usual three-phase transformer connections are the delta-delta connection, the star-star connection, the star-delta connection, and the delta-star connection. The first two connections are illustrated in Figs. 10 and 12.

In connecting transformers in the manner just described, care must be taken to make the secondary connections correspond with the primary connections in regard to relative polarities and phase rotation. If this is not done a short circuit may be caused with delta-connected secondary windings and incorrect voltages may be obtained with star-connected secondary windings. It is assumed, of course, that the transformers are all of the same ratio.

If the primary and secondary windings of the bank of transformers are both to be connected delta or star, it is an easy matter to get the connections right. After the primary leads have been connected up, test the secondary winding of each transformer to make sure they have the same polarity. Then connect the secondary leads from the three transformers exactly as the primary leads have been connected. If the transformers do not have the same polarities follow the instructions given in the following paragraphs.

If the primary and secondary are not to be connected in the same manner, that is, if one is to be connected delta and the other star or *vice versa*, the method just outlined cannot be applied, because of the difference between star and delta connections. In such cases, the primary windings should be connected up in the manner in which they are to be operated and the secondary connections tested out as follows.

For delta-connected secondary windings, connect two secondaries together as shown in Fig. 10, that is connect X_2 of the left-hand transformer to X_3 of the center transformer. The connections between X_4 and X_5 and at O are to be left open for the time being. Now measure the voltage from X_1 of the left-hand transformer to X_4 of the center transformer. It should equal the voltage measured across X_1 and X_2 or across X_3 and X_4. If it does the connection is correct. If the voltage across X_1 and X_4 is about 1¾ times the voltage of one transformer, reverse the secondary of either transformer, to correct that condition.

After having obtained the correct voltage between X_1 and X_4, connect X_4 to X_5 and measure the voltage between X_1 and X_6 as shown in Fig. 10. If the connection is right the voltage should equal zero. If the voltage is about twice the voltage of one transformer, the secondary of the third transformer should be reversed.

For star-connected, secondary windings connect X_1 to X_3 as shown in Fig. 12, leaving open the connection shown at O and measure the voltage across X_2 and X_4. It should equal about 1¾ (exactly 1.73) times

Fig. 14—Transformer banks having dissimilar connections should not be paralleled.
The diagram shows a delta-delta connected bank at the left arranged to be paralleled with the star-delta connected bank shown at the right. These banks will not parallel, due to their voltages being out of phase as is shown in the voltage diagrams.

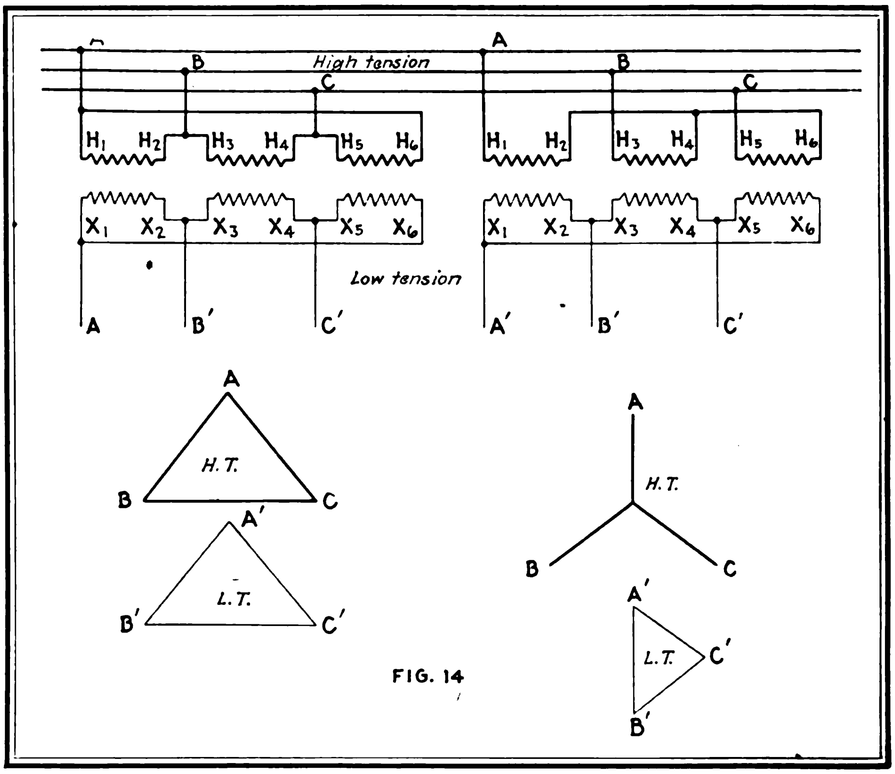


FIG. 14

the voltage across one transformer that is across X_1 and X_3. If the voltage measured across X_2 and X_4 should equal the voltage across one transformer, one of the secondaries must be reversed; that is X_4 must connect to X_1, and X_2 and X_3 will become the line wires.

After the first two transformers have been properly connected, one lead of the third transformer should be connected to the common wire of the other two transformers; that is X_5 of the third transformer should be connected to the wire connecting to X_1 and X_3 as shown in Fig. 12. The voltage measured between X_5 and X_4 or between X_6 and X_2 should be about 1¾ times the voltage of one transformer. If the voltage measured is equal to the voltage of one transformer then the connection of the third transformer is wrong, and the secondary of the third transformer must be reversed.

A connection using transformers of opposite polarity is shown in Fig. 11. The difference in the vectors of the secondaries should be noted. It will be seen that these two secondaries have the same phase angle but not the same polarity. In making a delta-delta connection it is possible to make an error in connecting and thus have one transformer in the bank with reversed polarity. This condition is illustrated in Fig. 13 and if the bank were thrown on the line a very heavy, circulating current would flow which would blow the fuses or open the oil switch. This emphasizes the necessity of checking (as indicated in Fig. 10) the last connection of the delta before completing the connection.

Three-phase current may be supplied by the use of only two single-phase transformers connected in open delta. In connecting two transformers in open delta, it is necessary to observe the polarity closely, particularly if transformers of different makes are used. This is shown in Fig. 9. It is possible to have nearly double voltage on one phase, due to incorrect connection. It should be observed that two transformers operating in open delta have only 86.6 per cent of the combined kva. rating of the two transformers. They should be loaded accordingly.

In paralleling banks of transformers, the individual units must have the same ratio, polarity and per cent impedance and must also be similarly connected; that is, a delta-delta connected bank cannot be paralleled with a star-delta connected bank, but should be paralleled with a delta-delta connected bank.

The effect of the method of connecting the transformers is very plainly shown by the connections in Fig. 14. Here are a bank connected delta delta and a bank connected star delta. The vector diagrams plainly contrast the difference in the phase angle of the two secondaries although the polarities of the secondaries are the same. The secondaries of these transformers could not be paralleled due to this angularity of 30 deg.

The two banks shown in Figs. 10 and 11 are of opposite polarity as can be seen by the arrows in the diagrams and by the voltage diagrams beside each figure. The secondary voltages of these two banks are 180 deg. out of phase and, therefore, they cannot be paralleled.

It is, then, a wise precaution to check up the relative polarity of the two banks of transformers before paralleling them. This may be done by connecting both banks of transformers on the high-tension side to the power supply. The low-tension sides of both banks are connected up as they are intended to operate but all of the parallel connections between the transformers should not be closed. One terminal only of each bank is connected to one of the common bus bars or parallel connections. Then the voltage is measured from each of the other terminals of one bank to the corresponding terminal of the other. If the polarities are alike the voltage will be zero. If the polarities are reversed, the voltmeter will read double the secondary voltage in each case. The remedy is to reverse (*Continued on page 602*)

Figs. 15 to 17—Method of testing three-phase transformers for parallel operation.

In Fig. 15 the high-tension sides of both transformers are connected to the power supply after one low-tension terminal of each transformer has been connected as shown. For the transformers to parallel correctly the voltages across *M* and *N* and across *O* and *P* should be zero. Figs. 16 and 17 show the effect of a transposition of low-tension leads in a three-phase transformer. Fig. 16 shows the way the connections were given on the nameplate of the transformer. Fig. 17 shows the way they were actually found. The voltage diagrams shown below each figure give the voltage relations. As can be seen, phases B' and C' would have to be interchanged on the low-tension side for parallel operation.

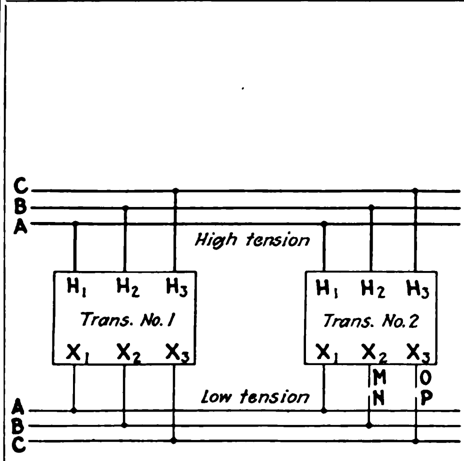


FIG. 15

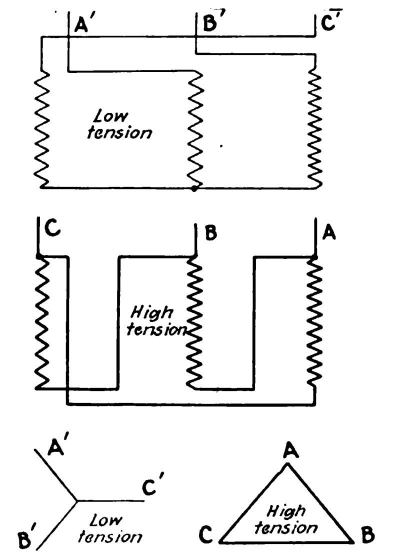


FIG. 16

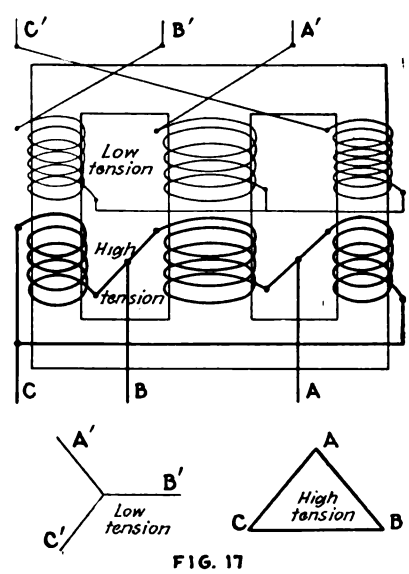
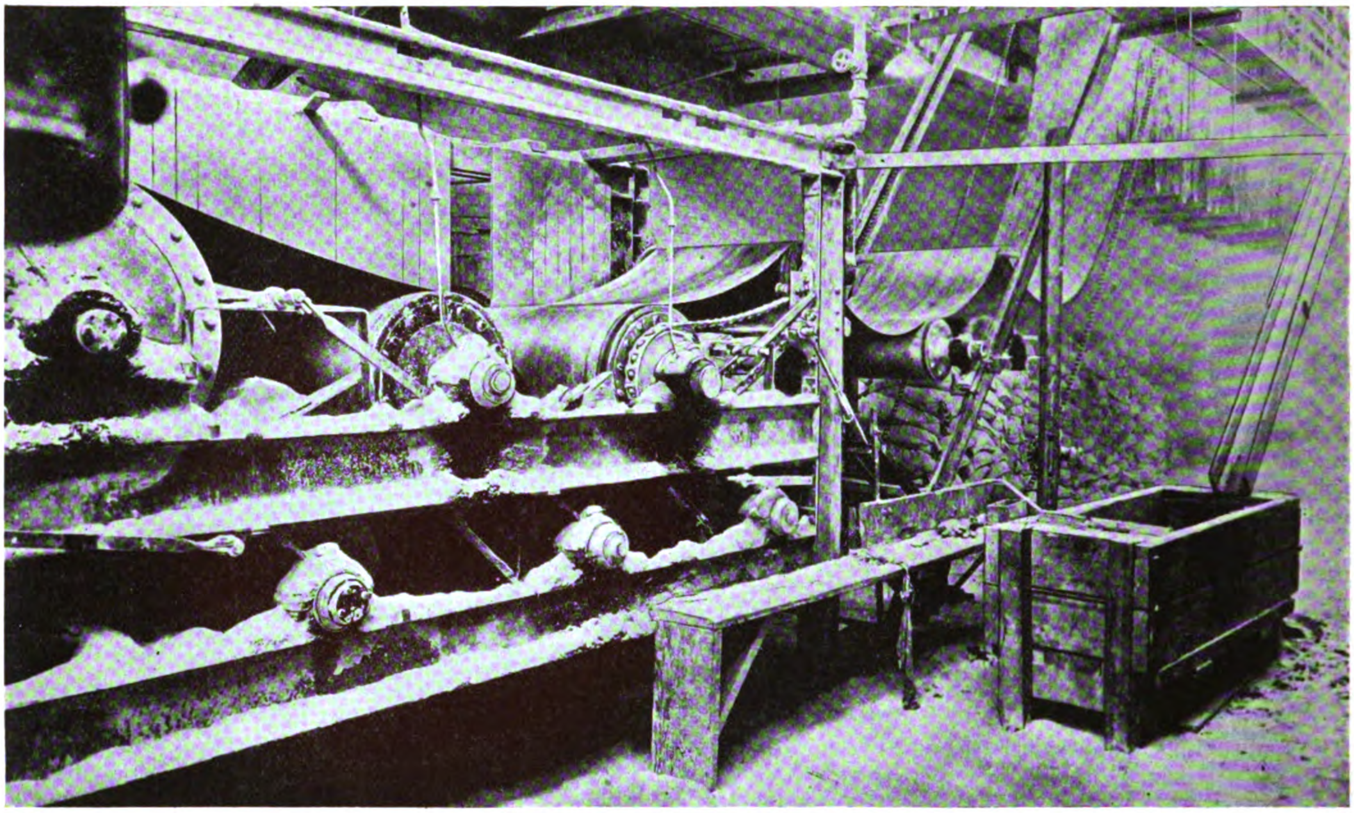


FIG. 17



This shows the coated felt passing from the water-cooled cooling cylinders to storage on the stick-type looper shown in Fig. 1 on the next page.

Some Relations Between

Maintenance and Operating Costs

In the Manufacture of Prepared Roofing Together with Details of Production and the Equipment Required

By J. L. McK. YARDLEY

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NO BRANCH of the building supply industry provides more opportunity for studies in raw material procurement, manufacturing operations and maintenance of equipment, and finished product distribution than does the manufacture of prepared or surfaced roofing, which is made principally from rag felt, asphalt and granular slate. This is necessarily not a localized industry. In fact, it is most successfully conducted when its national, or international scope is fully recognized. While in its application and selling ramifications it extends into the building industry in the remotest corners of the country, in its production it associates and links several of the world's most important industries while combining diverse raw materials. In the process involved in turning these raw materials into the finished product, a wide variety of equipment is employed, and the maintenance problems are many and varied.

Granulated slate is one of the important constituents of roofing and it is usually preferable to mine the rock rather than quarry it, so as to insure that it will be perfectly dry. Here is a crushing problem in which fine grinding is not desired. The granules must be uniform. Tests on samples of Vermont granules indicated that by weight 66 per cent of the product goes through No. 10 mesh and on to No. 20; 23 per cent goes through No. 20 mesh and on to No. 30, and 11 per cent goes through No. 30 mesh. The detailed construction costs of a Michigan plant having a capacity of 240 tons of granules per 8-hr. day are given below in Table I. The equipment was selected with a view to having as large a percentage as possible of the raw material crushed to exact size, with a minimum of fines and over-sized material. The property of about 400 ft. by 800 ft., containing about twenty acres, was leased. The cost of the crushing plant inclusive of clearing five acres of land, building an 800-ft. railroad siding and four-mile transmission line and the purchase and installation of 600 hp. in transformers, motors and control equipment amounted to almost exactly $150,000.

This plant took a 15-min. peak load as well as an average of 450 kw. for the 8-hr. day at a cost of approximately 2.53 cents per kw.-hr., making

a power cost of about 40 cents per ton. The material would be shipped at approximately $1 per ton, including labor and overhead.

An analysis indicated that a fuel-oil-engine power plant would have a total installation cost of $100,000 and a total yearly operating cost of $30,300 or 2.81 cents per kw.-hr. A steam turbo-generator power plant would have a total installation cost of $95,210 and a total annual operating cost of $31,877 or 2.95 cents per kw.-hr. It would also require about 1,000 gal. of water per minute for boiler feed and condensation purposes. It was accordingly found economical to purchase power, particularly as the power company agreed to return $6,500 by deductions from power bills.

Table I—Construction Cost of Slate Granulating Mill

Item	Cost
Railroad siding, 800 ft. at $50 per ft.	$ 4,000.00
Clearing five acres of land at $200 per acre	1,000.00
Construction of 4-mile transmission line, erection of transformers	8,000.00
Cutting away rock from hill for mill site at $50 per yd.	1,000.00
Well, 50 ft. deep, for drills, buildings and heating boiler	500.00
Telephone installation	100.00
Machinery complete	60,000.00
Motors and starters, 600 hp. at $25 per hp.	15,000.00
Installation of machinery and motors	8,000.00
Mill building, including lighting system	10,000.00
Combination office, supply room, first aid dept. and home	4,000.00
Equipment for combination office	2,000.00
Machine shop building	1,500.00
Machine shop equipment	5,000.00
Change house and equipment for workmen	5,000.00
Heating system and plant	3,000.00
Concrete foundations	2,000.00
Powder storage shed	600.00
Storage bins, material and labor	6,000.00
Transformer station	3,300.00
Plans, designs, specifications, engineering and construction supervision	10,000.00
Total	$150,000.00

Equipment and Operation of Roofing Felt Mill

The manufacture of felt is similar to the manufacture of paper, where cylinder-type machines are employed. The class of labor is the same and in general the machinery employed is the same as in the board mill. The felt machine usually employed produces a roll 72 in. wide, which is slit into two rolls 36 in. wide. One difference is that the pulp mill and the extensive use of power in this industry is done away with, as the raw rag material does not require grinding, although it does require cutting into shreds and the cutter is the first machine the rags encounter in the flow sheet as they leave the rag storage. There are, of course, modifications due to local conditions but, in general, all felt mills are about the same.

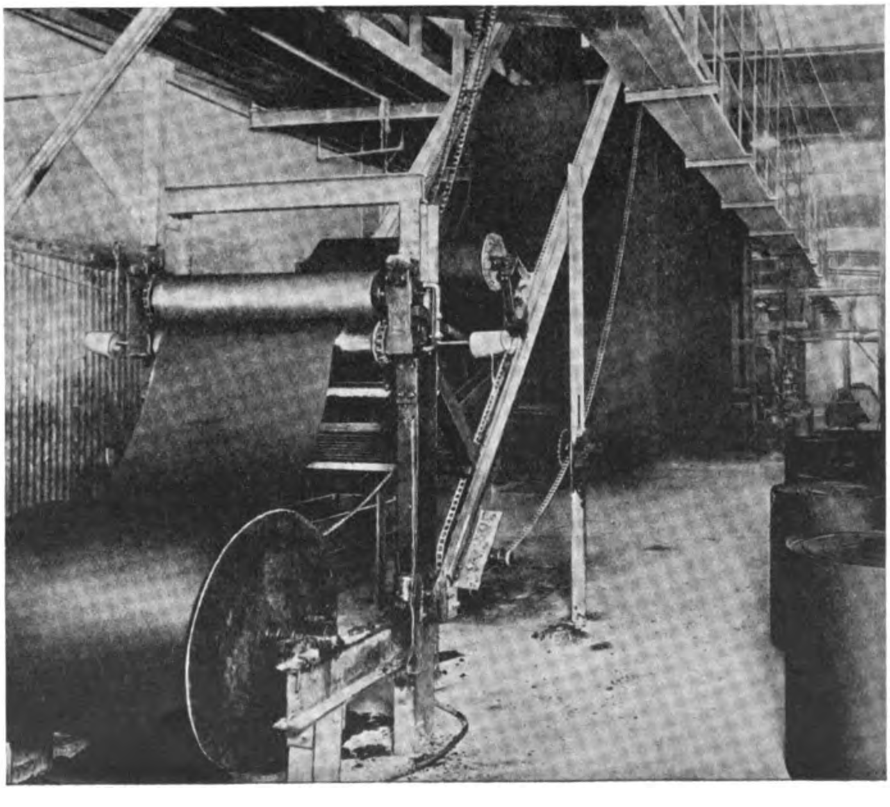
The usual felt mill is exceedingly inefficient in the use of power and steam. Felt mills are generally self-contained; that is, they generate the power which is required, and largely as a by-product in obtaining the steam which is required in drying. This is a problem which is susceptible of being worked out very nicely through the application of proper engineering principles.

There is need for good consulting engineering in this industry and competition will probably make this still more apparent in the future. Some of the best mills produce a little more than a pound of felt for each pound of coal burned. Others which I have known are woefully inefficient, requiring two pounds of coal per pound of felt. The reason for such a discrepancy is that the cost of power and steam, even when inefficiently used in the self-contained mill, is still but a small part of the total cost of manufacture of felt. This is shown by the cost analysis given in Table II of a week's operation of a three-machine mill having a capacity of about seventy-five tons of felt per day and an over-all valuation of approximately $1,000,000. Such analyses probably explain why power and steam losses have not been determined and corrected to the same extent that they have been in the paper-making industry, for example. It will also be seen from this table that the cost of maintenance and repairs is by far the largest item of expense for the total non-productive labor.

Of the total of $2,135.62 for non-productive labor, $1,747.55, or 81.8 per cent, was spent for repairs and

Fig. 1—Stick-type looper for cooling felt after saturation in roofing machine.

In addition to cooling the felt this type of looper compensates for irregularities in the rate of production. As shown here the felt is being wound on a reel after passing through pull rolls.



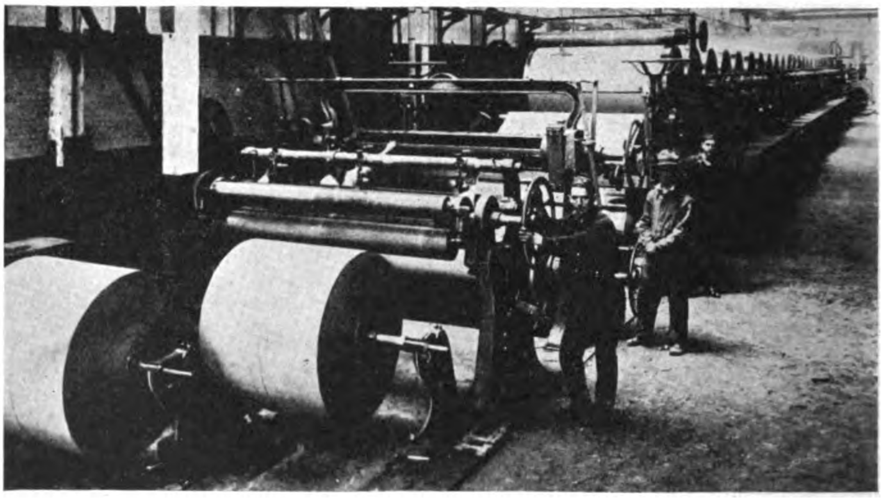


Fig. 2—Finishing end of felt making machine, showing steam heated drying cylinders, which put the felt in condition for saturating.

maintenance of equipment and buildings. This table is typical, although it covers a high-cost period during 1920 at which time a roofing plant on the Pacific Coast paid anywhere from $126 to $146 per ton for felt locally produced and from $150 to $185 per ton for Eastern felt. The Eastern felt included nearly $25 freight to San Francisco and the Western felt, $5.50 from Los Angeles or $1 from local source. A profit of $50 per ton for an output of seventy-five tons per day, means a total profit of more than $1,000,000 per year for the felt mill.

Layout and Operation of the Roofing Mill

The layout of the roofing mill is of the utmost importance from a production point of view. Here the problem is to maintain and deliver a water-free felt to the saturating machine, saturate it and coat it with asphalt and an even layer of slate granules at a high temperature, cool it and wind it into rolls or cut it into shingles for shipment. The total amount of power employed is small, being in the neighborhood of 60 hp. for a continuous saturating, coating and shingle-cutting unit. About 35 hp. are required for the saturating and coating machines and cooling rolls, 10 hp. for the cutters and 10 hp. for the dryers when used in advance of the saturating machine, and for the beginning rolls. Whereas in the felt mill the cylinders filled with steam were used to dry out moisture, in the roofing mill the usual function of the cylinders is to cool and harden the saturated and coated felt before it is rolled or cut into shingles, and for this purpose they are supplied with a constant stream of cool water. Usually, however, the cylinder coolers are supplemented or often largely supplanted by stick-type looper coolers such as shown in Fig. 1.

The biggest machine output is obtained by entirely separating the saturating and coating processes. Splices may be made after the felt has been saturated. Spraying of the saturant on the felt is being considered, although the usual method is to run the felt through a tank of saturant maintained at a suitable temperature by heating coils. The saturant temperature employed varies from 420 deg. F. to 350 deg. F. The latter is best practice, in which case two saturating machines are used for one coating machine. As a coating temperature of 360 deg. F. to 370 deg. F. is maintained by steam coils in the tank cars, high-pressure steam, above 150 lb. is necessary. The stick-type looper is generally considered the best. It should be of ample capacity, particularly where located between saturating and coating machines in a continuous unit, for the purpose of preventing momentary troubles at one machine reducing the production of the other. A preferred layout would include:

FORM 334 5M 8-16-20

PLANT ____________

DAILY MACHINE REPORT

[redacted] ROOFING COMPANY

MACHINE NO. ____________ DATE ____________

KIND OF ROOFING	PLY	PRODUCTION SHGL. FIRSTS	SQS. SEC	SQS. OF 108 SQ. FT. FIRSTS	SEC.	THDS	AV. 1ST'S PER HR.	HOURS OPERAT'G	ACT'LY RUN'G	TIME LOST	REASON (GIVE NO.)	WT. PER SQUARE	TOTAL WEIGHT
TOTALS			— %		%	%							

ACCOUNT FOR DELAYS AND TIME LOST IN SPACES PROVIDED BELOW:

Felt Troubles.	Broke where?	Minutes
1......Breaks Holes in felt		
2...... " Crushed felt		
3...... " Broken torn edges		
4...... " Thin spots		
5...... " Not strong enough		
6...... " Poor splices		
7...... " Wet felt		
8...... "		
9...... "		
10		
11		
12		
13		
14		
15		
	Total	

Felt Waste

Dry	..........lbs.
Saturated	..........lbs.
Coated	..........lbs.
Finished	..........lbs.
Total	..........lbs.

Daily operation	..........hrs.
Less time lost	..........hrs.
Actual day's run	..........hrs.

REMARKS:

MECHANICAL:	Min.
16 Belt and drives	....
17 Motors and electrical	....
18 Hoppers	....
19 Pumps	....
20 Winders	....
21 Clutches	....
22 Elevators	....
23 Slitters	....
24 Shingle Machine	....
25 ________	
26 ________	
27 ________	
28 ________	
Total	________

GENERAL:	Min.
31 Pumping back	....
32 Waiting for sat.	....
33 " " coating	....
34 Cold saturation	....
35 " coating	....
36 Changing over	....
37 Coating lines plugged	....
38 No power	....
39 Steam rolls	....
40	....
41	....
42	....
43	....
Total	________

SIGNED ____________ MACHINE FOREMAN

Fig. 3—This machine report gives a complete record of the operation of a roofing mill.

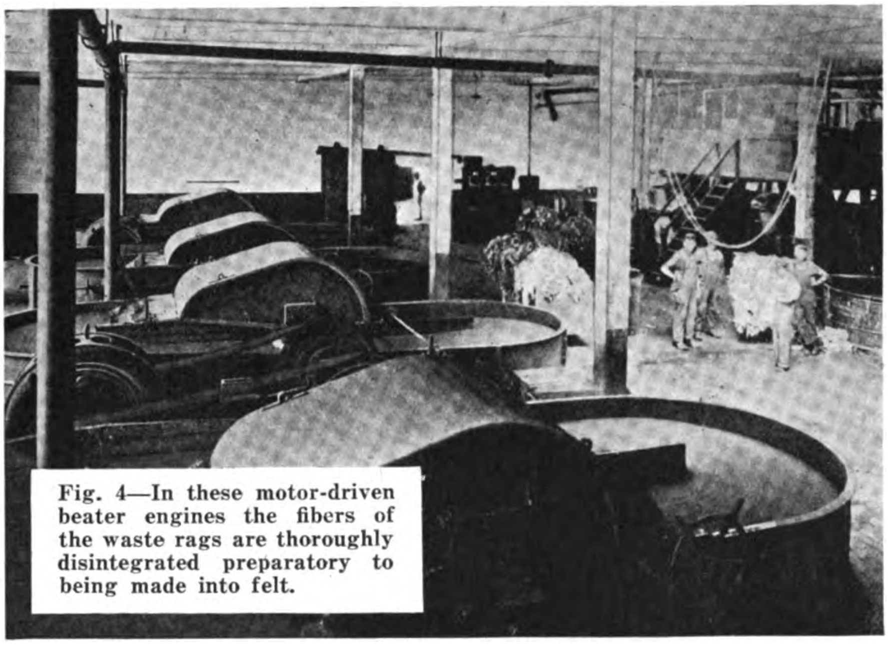


Fig. 4—In these motor-driven beater engines the fibers of the waste rags are thoroughly disintegrated preparatory to being made into felt.

(1) A looper for dry felt.
(2) A simple saturating section and reel winder for saturating felt.
(3) A conveyor so that a series of reels may be carried and set up in place for the coating section.
(4) A coating section with another looper.
(5) A simple set of coating rolls, probably two, and means for distributing slate evenly upon the coating.
(6) A stick looper with squeeze rolls installed in place for embedding the slate.

This equipment if installed on sound foundations with everything of the best should have an output for a single width machine of 300 squares of slate-surfaced roofing or 400 squares of smooth surfaced roofing per hour. A "square" is roofing sufficient for 100 sq. ft. of roof surface. At about 85 lb. for the one or 55 lb. for the other, this represents an output of about 12 tons per hour. When manufactured into shingles at the usual 240 lb. per square, the output per hour is slightly over 100 squares. These are usually shipped in four packages to the square. A daily machine report form covering the operations of the roofing mill is shown in Fig. 3.

Equipment Required in Roofing-Asphalt Refinery

The hourly output of one machine making slate-surfaced roofing will require approximately 3 tons of granules, 3 tons of felt and 6 tons of saturant and coating. These figures give a rough idea of the production demand upon the granulating mill, felt mill and refinery.

The industrial use of asphalt is growing rapidly. In the roofing trade particularly, all guaranteed and first-grade roofing is made of prepared felts saturated and coated with asphalt. In the saturation process use is made of an asphalt which is soft enough to impregnate the felt without excess, and a hard, high-melting point material is used as a coating, to protect against abrasion and weathering. The saturant is obtained by distilling crude petroleum and the coating is obtained from the impregnating asphalt, by a further process of oxidation, either by a vacuum system or by blowing at high temperatures. The product is spoken of as a blown asphalt. The effect of the blowing or oxidizing treatment is to produce a coating material which may be looked upon as dehydrogenated and condensed, so far as its molecular structure is concerned. This operation may be performed at the refinery and the blown asphalt shipped in drums. Coating obtained and shipped in this manner from an uncontrolled source has been about

Table II—Operating Expenses of Felt Mill for One Week

During this period there were 176 employees, and 398 tons of felt were produced.

	Operation	Total	Per Ton
	Productive Labor		
1.	Sorting and cutting	$ 702.90	$1.77
2.	Beater men	1,233.22	3.10
3.	Trucking—beater room	145.20	.36
4.	Machine tenders	578.63	1.45
5.	Cleaning and oiling	56.65	.14
6.	Testing and winding rolls	180.58	.45
7.	Receiving rags	400.72	1.01
8.	Receiving paper	34.10	.09
9.	Receiving coal	72.74	.18
		$3,404.74	$ 8.55
	Non-Productive Labor		
10.	Repairs, rag cutting machines	$ 115.50	$0.29
11.	Grinders, cutting knives	31.24	.08
12.	Repairs to paper beaters	7.62	.02
13.	Repairs to rag beaters	111.16	.28
14.	Repairs to chests	67.60	.17
15.	Repairs to Jordans	1.66	.005
16.	Repairs to sundry equipment	113.72	.29
17.	Repairs to No. 1 machine	58.97	.15
18.	Repairs to No. 2 machine	51.91	.13
19.	Repairs to No. 3 machine	42.38	.11
20.	Repairs to machine room equipment	12.18	.03
21.	Engineer and fireman	431.50	1.08
22.	Repairs to boilers	5.94	.015
23.	Repairs to stokers	5.54	.015
24.	Repairs to boiler house equipment	273.82	.685
25.	Repairs to pumps	90.54	.23
26.	Repairs to electrical equipment	58.08	.14
27.	Repairs to motors	27.08	.07
28.	Repairs to water tower	6.30	.02
29.	Repairs to locomotive crane	63.05	.16
30.	Repairs to machine shop equipment	4.56	.01
31.	Repairs to machine rooms	148.80	.37
32.	Shipping labor	151.55	.38
33.	Watchmen and janitors	57.30	.14
34.	Drivers	127.63	.32
35.	Miscellaneous building repair	21.40	.05
36.	Miscellaneous expense	51.59	.13
		$2,135.62	$ 5.37
	Grand total labor	$5,540.36	$13.92
	Cost of rags at platform		78.00
	Cost of coal, two tons per ton of felt at approx. $4.00		8.00
	Total cost of felt per ton		$99.92

50 per cent more expensive than saturant. However, a number of roofing mills have found it preferable to avoid the expense of drums by shipping all asphalt as saturant and blowing the necessary coating at the roofing mill, making as large as possible a use of tank cars.

The industry practically justifies a refinery devoted primarily to its own requirements. In addition to the large tonnages of saturating and coating asphalt demanded, there is a large field for refinery distillate products in the manufacture of mastic cushions for roofing tile, roof repairing cements, and cold roof paints. These products are manufactured with very small labor cost. A Pacific Coast plant during 1920 with only five men in the paint factory and with suitable equipment in less than 4,000 sq. ft. of space had a monthly capacity of 12,000 gal. black, 5,000 gal. red, 5,000 gal. green and 8,000 gal. brown roofing paint, 15,000 gal. shingle stains, 8,000 gal. concrete paint and 40 tons of elastic cement.

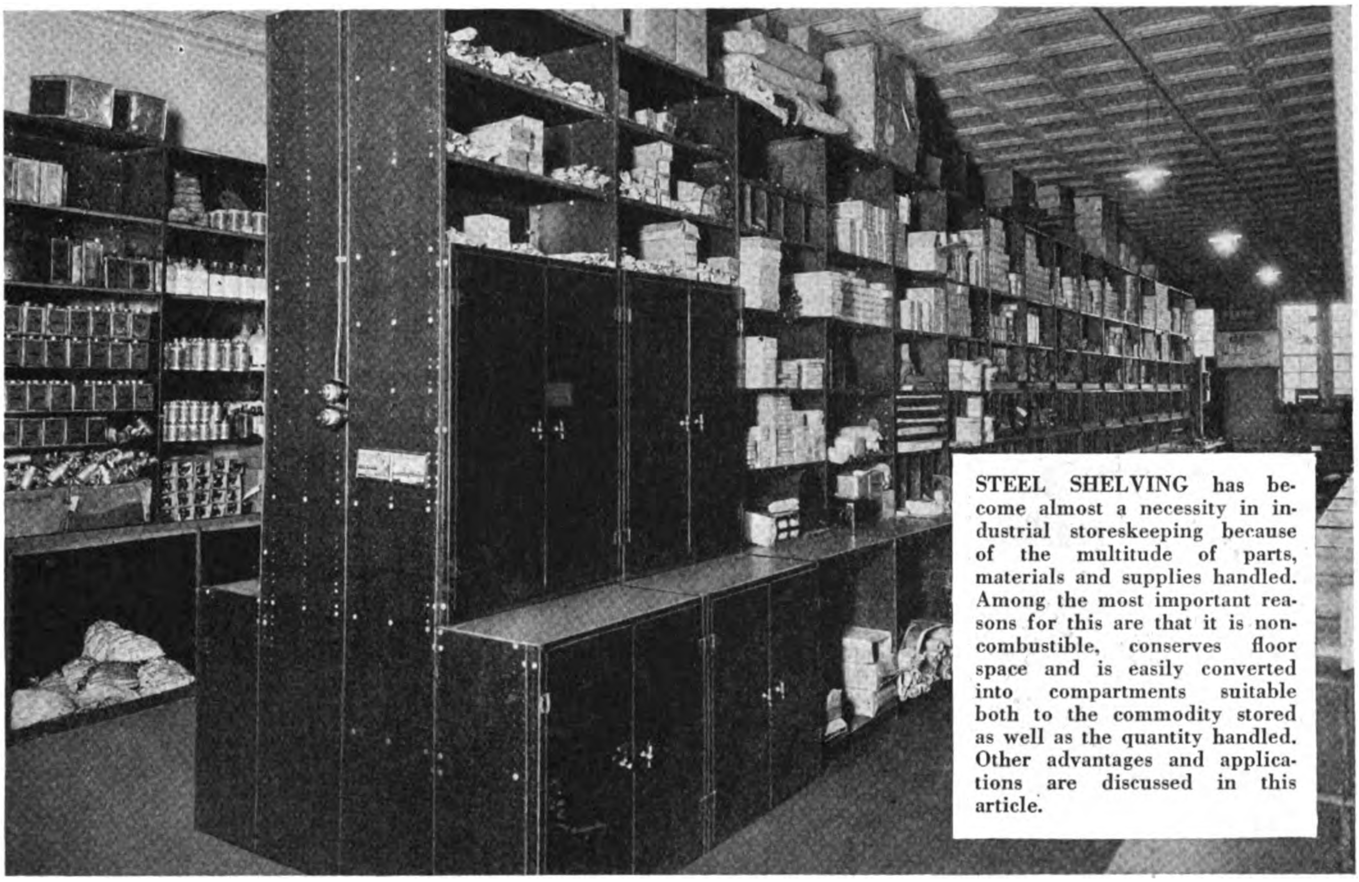
Detailed costs covering one week's operation of a four-machine roofing mill, disclosed several facts which are perhaps typical of such a plant and indicative of results which are sometimes obtained actually, as compared to what it appears might be obtained. The operation was one full shift for six days per week. Notable points are that for seventy machine-hours the machines were down because of no working orders; for one-fifth of the remaining available time, the machines did not deliver output owing to miscellaneous delays. The machines actually worked in production a total of only approximately 126½ machine-hours during the week. They produced in that time a total of 23,817 squares of smooth and slate-surfaced roofings, 9,038½ squares of which went into shingles. While producing their ouput was at the rate of only 188 squares per machine-hour and at a total labor cost of 24½ cents per square.

The cost of maintenance and repairs during this period is also of interest. Of a total of $5,840.11 chargeable to roofing production, $2,918.32, or approximately 50 per cent, was non-productive labor cost, such as yard labor, drivers' and chauffeurs' wages and so on. Of this non-productive labor, in turn $713.15, or 24 per cent, was charged to maintenance and repairs to buildings and equipment.

The amount and character of the equipment required for a crude petroleum refinery, for the roofing industry, with a yearly capacity of 1,138,800 bbl., is shown in Table III. This refinery was designed for a location on the lower Mississippi. It is laid out for the receipt and storage of crude oil from tankers and for the rail shipment of the refinery products. (*Continued on page 601*)

Table III—Estimated Cost of Equipment of Crude Petroleum Refinery for Roofing Industry

No.	Item	Cost
	Real Estate	$ 50,250.00
3	55,000 bbl. tanks, $25,000 each, $12,000 const	111,000.00
3	12,000 bbl. tanks, 9,500 each, 3,400 const	38,700.00
5	5,000 bbl. tanks, 4,900 each, 1,650 const	32,750.00
2	2,000 bbl. tanks, 3,100 each, 950 const	8,100.00
2	1,000 bbl. tanks, 2,000 each, 600 const	5,200.00
1	60'x10'x4' O. T. tanks, $2,200 each, $600 const	2,800.00
1	6'x4'x4' O. T. tanks	250.00
1	4' dia., 6' high x ½"	350.00
1	90'x40'x12 O. T. tank, $17,000 each, $4,000	21,000.00
2	30'x15'x12 O. T. tanks, 2,000 each, 600	5,200.00
1	Separator, $4,000 each, $1,200	5,200.00
6	Stills, 42'x14'6", $7,000 each, $2,100	54,600.00
3	Stills, 30'x5', $3,000 each, $750	11,250.00
1	Water tower, 50,000 gal	12,000.00
3	350 hp. B. & W. boilers, $28 per hp., $15,000 each	45,000.00
1	2,000 hp. Swartout boiler feed heater, $1,750, const. $422	2,172.00
2	Foster super heaters, 10,000 lb. capacity, $4,700, const., $420, $2,000	11,820.00
26	Hammel fuel oil burners, $40.00 each	1,040.00
1	Hammel fuel oil set, 6x4x6	1,850.00
1	W. S. compound pot valve plunger pump, 14"x25"x10"x24"	10,500.00
4	W. S. piston pot valve pumps, 14"x10½"x18", $2,500	10,000.00
2	W. S. piston box pumps, B. L. 14"x10½"x18", $2,950	5,900.00
3	W. S. piston box pumps, B. L. 9"x7"x15", $2,200	6,600.00
2	W. S. plunger pot valve pumps, B. L. 10"x7"x18", $2,400	4,800.00
1	Buffalo Underwriters fire pump, B. L. 18"x10"x12"	2,090.00
2	Box B. L. 7½"x6"x10", $550.00	1,100.00
3	Kinney pumps, motor size 12-8-8, strainer, $2,662	7,986.00
2	Motor-driven water pumps	1,200.00
2	Motor-driven geared oil pumps for trap	1,200.00
6	3" Fisher governors, $65.00	390.00
2	No. 4 P. H. & F. M. Roots gas exhausters	3,246.00
1	3-ton ice plant	
1	400' wharf and approach	54,000.00
	Buildings complete	73,600.00
	Still and condenser foundations—brick work	38,850.00
	3,900 ft. switch track, $6.00 per ft	23,400.00
2	10" water wells	4,700.00
1	River water filter plant	4,450.00
	Lumber—form and scaffolding	1,850.00
	Pine	75,454.20
	Pipe fittings and pipe covering	44,463.76
46	"I" beams—15 lb. 40' long, 77,280 lbs. at 5 cents lb	3,864.00
	Steel stairways and walkways	1,052.00
	710 ft. Cyclone 7' fence	1,313.50
2	200-kw. generators, turbine	22,600.00
1	Oil trap, 50'x20'	6,724.00
	Electric light and motor installation	11,797.00
2	Air compressors	10,000.00
2	Radial brick stacks, 125'x90" at $8,724	17,448.00
	Switch engine	14,000.00
	Machine shop and equipment, tools, complete	11,438.42
	Electric welding outfits	2,460.00
	Foamite installation	48,790.00
	Local telephone system	3,500.00
12	Houses and bunk house and dining room	48,000.00
748	Piles and driving	11,168.00
	Concrete mixer with gasoline engine	1,300.00
	Team mules	600.00
	Wagon, plow, scrapers and mowing machine	1,280.00
2	Concrete tanks, 30'x60'x4', for water	4,875.00
	Rope, blocks, shackles, shovels, picks, wheelbarrows, etc.	2,000.00
2	Trucks, one 5-ton and one 2-ton White	7,300.00
	Automobile—Ford	500.00
	Laboratory testing equipment	1,840.00
	Steam hoisting engine	4,000.00
	Roads, sidewalks, sewers, ditching, etc	810.00
	Cement sidewalks	2,171.00
	Material and labor for equipment not shown	10,000.00
	Total	$1,047,142.88



STEEL SHELVING has become almost a necessity in industrial storeskeeping because of the multitude of parts, materials and supplies handled. Among the most important reasons for this are that it is non-combustible, conserves floor space and is easily converted into compartments suitable both to the commodity stored as well as the quantity handled. Other advantages and applications are discussed in this article.

With miscellaneous material it is often desirable to make compartments in a variety of sizes, as above. Valuable material may be locked in the cabinets.

Modern Practice In the Use of

Shelves and Racks in Industrial Storerooms

For Storing Miscellaneous Repair and Maintenance Parts and Supplies as Well as Material both Before and After Manufacture and Between Operations During Work in Process

By FRANK E. GOODING
Associate Editor, Industrial Engineer

FACTORY housekeeping depends upon having adequate and proper storage space. It is impossible to go far in attempting to retain factory material, tools and supplies in orderly arrangement without storage facilities. For this purpose bins, open or closed types of shelves, and racks are most commonly used, not only because of the neat arrangement possible, but also because they multiply the amount of storage possible on a given floor space. Shelves from four to ten tiers high, provide storage space of approximately that many times the amount which could be stored on a similar floor area. This is a big advantage, as floor space is expensive. Also, when materials are stored together in good order they can be indexed, and located much more easily than if it were necessary to search around for them. Permanent storage spaces enable this to be done, whereas, if the material was promiscuously piled around on the floor, it would not be as easily nor as likely, to be indexed or located so specifically. Other advantages will be brought out later in this article.

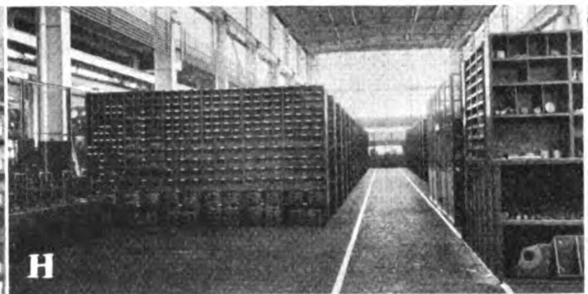
Wood and steel are the materials most commonly used for the construction of storage shelves. The objection that is raised against the use of wood is that it is combustible and will help feed any fire which may get started in the storeroom, even though the material stored is non-combustible. A fire will destroy or at least decrease the value of practically any line of material stored. Many manufactured parts when stored have a thin coating of oil which helps to retard rusting. This soaks off into the wood and makes it a still more dangerous fire hazard.

Also wood storage shelves cannot be made as strong in the joints. Neither can they be made, easily, in a form which can be knocked down for shipment, erected anywhere and then dismantled to be moved and erected again. Another objection is that after making wood up into bins or cabinets, it is practically impossible to enlarge the spaces without destroying or entirely rebuilding the bins. Other disadvantages may be easily seen from the contrast to the advantages of steel which will be given later. These, together with

Some Typical Installations of Steel Shelving

How This Equipment Is Used in Thirteen Plants

A



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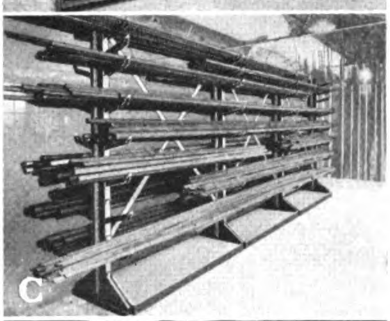


C

D

E

F

A—An example of ledge-style of closed shelving with bin front to carry cards indicating contents and divided into various sizes of compartments for handling miscellaneous material.

B—An example of open-type shelving for pattern storage with permanent movable ladder.

C—Pressed steel bar rack for storing pipe, shafting or steel bars. The arms are adjustable in height.

D—Open-type shelving supporting a heavy load of lithographing stones. The shelving is built around a locker installation in the far end of the room.

E—These closed shelves with large bin front support about 3,000 pounds of brass valves per shelf.

F—For storing extra long material two to four units of shelving are placed together without backs.

G—Closed shelving provided with drill inserts instead of shelves for use in a tool room. Each compartment has a hook for the brass check which shows who has received a tool.

H—A good example of a well-arranged store-room which is served by an overhead traveling crane. The first unit at the right shows how long materials may be stored.

I—This shelving is made of 12-gage steel designed to carry a load of 500 lb. per sq. ft. The ledge, however, is meant to work on and not as a place to pile material.

J—An example of convertible ledge style closed-type shelving with bin front in the lower sections and dividers making a variety of sizes of open compartments in the upper section.

K—An example of double-ledge shelving which gives considerably increased depth to the lower shelves.

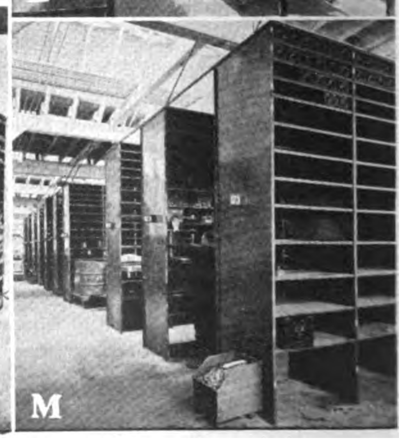
L—This shows how neatly miscellaneous materials may be arranged on open or skeleton shelving.

M—Instead of subdividing the shelves into compartments, this concern has standardized on units 3 ft. wide, 3 ft. deep and 11 ft. high with steel boxes for storage of small articles. The shelves are spaced as required and have a $\frac{3}{8}$-in. x 1-in. channel reinforcement front and back.

J

K

L



M

G

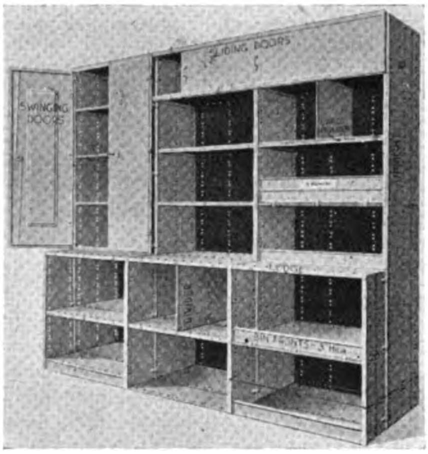
The space-saving advantages of steel over wood are well shown here.
A gain of 20 per cent in storage capacity is made by using steel boxes instead of wood. Also the steel boxes are slightly deeper. The same advantage is obtained in the use of steel shelving instead of wood. In addition, steel shelving is noncombustible, does not loosen at the corners and will not wear from contact with sharp materials.

the additional fire hazard, have made wooden shelves and storage racks or bins less desirable. Still, they are often put in "temporarily" and all together too often are permitted to remain. Practically the only advantage of wooden equipment is that it can be home-made. This advantage is, however, often more than offset by its undesirable features. Also, even though such equipment is home-made this does not always mean that its cost is low.

Steel construction has so many advantages, however, that it is practically the only recommended material for bin or shelf construction. The first of these advantages is that steel is non-combustible. It does not soak up oil from machine parts in storage and so become combustible. Accumulations of dust or oil can be cleaned off at any time the bin is empty, if desired. Probably the next most important advantage of steel is in the ease with which it can be set up, added to or dismantled for re-assembly somewhere else.

Several types of standard shelvings are available, some of which are shown in the accompanying illustrations. In general these may be classified as closed types, when sides and backs are added and the shelves further subdivided into bins, and open-type shelving without sides or back. These are made to provide for several standard depths. The shelves near the floor are usually larger and are used to take care of the heavy materials or those which are in large quantities. Sometimes the bottom shelf rests on the floor or is left out so that the material rests directly on the floor. Usually it is better to set the bottom a few inches from the floor, particularly if on concrete floors which are to be cleaned by flushing with a hose. Under ordinary conditions a dust-proof setting may be made by keeping the bottom shelf off the floor a few inches and putting a bin front, which will be described later, under the front edge to close it off. In many cases, however, when this space underneath is left open it merely becomes a "catch-all."

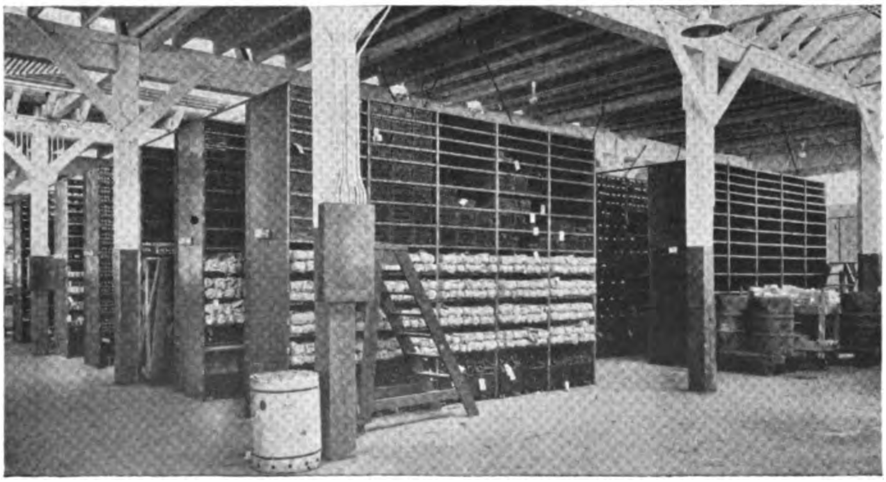
One manufacturer makes closed-type shelving in the following standard dimensions: Standard unit heights of 4 ft., 5 ft., 6 ft., 7 ft., 8 ft. and 10 ft.; standard unit depths of 11¾ in., 14¾ in., 18 in., 24½ in. and 30½ in.; standard unit widths of 18 in., 24 in., 30 in. and 36 in. These may be used to make a variety of combinations, or units with as many shelves as desired inserted. The frame, back and side pieces are punched so as to permit of the shelves being spaced with a vertical adjustment of 2 in. or 3 in., depending on type. Each shelf is fastened to the two end pieces and also to the back. In addition, it is either crimped or bent in such a way as to brace it along the front. For very heavy loads special bracing, angle-iron reinforcement in some cases, is inserted in the shelves to add strength.



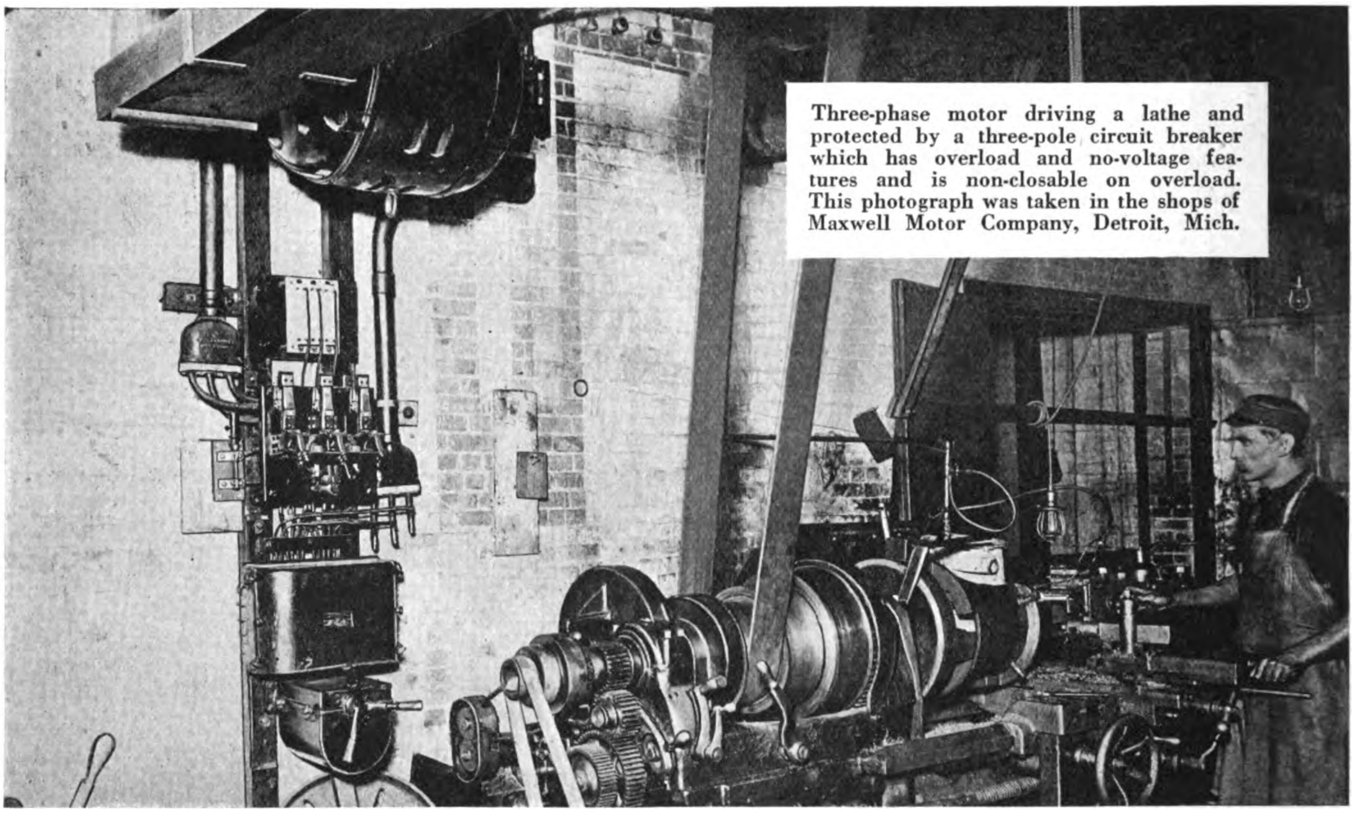
Make-up of three units of closed-type steel shelving.
The sections or units are separated by uprights extending from the floor to the top or distance *A*. The width of the unit is indicated by *C* and the depth by *E*. In this case a separate ledge, with a depth *D* and height *B*, is attached to the front, which increases the capacity of the lower compartments. The number of the compartments may be increased by adding dividers. Here the bottom plate rests on the floor. Sometimes it is omitted; in other cases it is raised 3 in. from the floor and a bin front inserted to close opening. Swinging and sliding doors, bin fronts and card holders may be used as shown. Frequently units are placed back-to-back, double-faced, to conserve space.

The shelves may be further subdivided into sections or compartments by vertical dividers which are also spaced on 2- or 3-in. adjustments, the same as the vertical adjustment. These dividers are supplied in different heights in the same increment as the vertical adjustment spacing. To change the size of a compartment, it is only necessary to move a shelf up or down and increase or decrease the dividers both in height and in number to get an entire change in the shelving. This can usually be done without interfering with the remainder of the section.

When it is desired to make the lower shelves deeper a ledge may be added to the bin front. These are usually 3 ft. high and are made by one manufacturer in standard depths of 6 in., 9 in., 12 in. and 15 in. This gives (*Continued on page 602*)



A typical industrial installation of steel shelving.
All units in this installation are 3 ft. wide, 3 ft. deep and 11 ft. high with plete uprights. The shelves have a ⅜-in. by 1-in. channel reinforcement front and back. The lower shelf is left out and the space used for steel boxes on casters. The top of shelves should be 18 in. below sprinkler heads.



Three-phase motor driving a lathe and protected by a three-pole circuit breaker which has overload and no-voltage features and is non-closable on overload. This photograph was taken in the shops of Maxwell Motor Company, Detroit, Mich.

Points to Consider When Using

Circuit Breakers for Feeders and A. C. Motors

Together With Details of the Range of Protection That Can Be Provided Under Different Operating Conditions

By JAMES H. WYATT

Assistant Engineer, Cutter Electrical & Manufacturing Company, Philadelphia, Pa.

PROTECTION NEEDS for circuits and equipment are largely determined by the operating conditions met with in an industrial plant. When installing a circuit breaker for any purpose the range of operating conditions should be thoroughly understood. Among the things that must be considered are the nature of the load, the kind of motor used, the method of starting, the method of control and the class of operator. This article analyses the influence of each of these factors and then points out the suitability of various types of breakers to meet different conditions. Alternating-current service only is considered here, since a similar article on direct-current service was published in the November, 1923, issue of INDUSTRIAL ENGINEER.

PROTECTION of alternating-current motors by means of circuit breakers requires some features which are not necessary in protecting direct-current motors. The latter subject was treated in an article by the writer in the November, 1923, issue of INDUSTRIAL ENGINEER. The following article covers the same ground with regard to alternating-current motors. It also includes the protection of feeders for light or power service.

Single-phase, alternating-current motors may be protected in the same way as direct-current motors. It is true, however, that the starting currents of single-phase motors are usually higher than those of direct-current motors of the same rating, and this fact must be taken into consideration when choosing a circuit breaker.

In the use of circuit breakers for the protection of polyphase motors, due consideration must be given to the characteristics of the particular motor in question with special reference to the current required in starting as compared with that required by the normal load of the motor. This ratio will be found to vary considerably with different types of motors and different methods of starting. Oudin, in his book on "Standard Polyphase Apparatus and Systems," gives the data in Table I for some makes of motors with short-circuited armatures started at various percentages of the full-line voltage by means of auto-transformers or compensators employed to reduce the voltage at the terminals of the motor during the starting period.

From the data in Table I it will

be seen that when a motor of the short-circuited or squirrel-cage type of rotor is started by being thrown directly across the line, the starting current may be as much as seven times the full-load current. It is quite common practice to start motors of 5 hp. and less in this manner, but the method is obviously unsuitable where lights are operated from the circuits which supply the motors. It will at once be seen that where a motor of the type under discussion is started directly on the line, the maximum instantaneous current flow resulting therefrom cannot be exceeded by any other condition of load, either normal or otherwise. In view of this the ordinary form of overload circuit breaker is unsuitable for the protection of this class of motor. If adjusted to afford any protection whatever during running conditions, the circuit breaker will inevitably be opened by the heavy current incident upon starting. A circuit breaker for this kind of service must, therefore, permit the passage of the starting current for the necessary period, it must interrupt this starting current if unduly continued, and when the motor is running it should be responsive to sustained overloads above a predetermined value which may be considerably less in magnitude than the starting current. These conditions are well met by a circuit breaker having a time delay inversely proportional to the current.

With motors of 5 hp. and upwards it is customary to limit the current at starting by means of a compensator. This is an auto-transformer which gives a reduced voltage for starting. The starting of the motor is usually effected by a double-throw switch by means of which the motor is first connected into circuit through the auto-transformer and then thrown directly across the line. The coils of the starting device are usually provided with a number of taps so that the proportion of full voltage which will be applied to the motor with the switch in the starting position may be determined in accordance with the starting torque required. Where this is small, say one-third that corresponding with full load, the starting voltage need not be over 40. per cent of line voltage and the line starting current will exceed the full-load current by only about 12 per cent. The current flowing from the auto-starter to the motor will be greater than the line current in the proportion that its voltage is less, because the energy inflow and energy output of the auto-starter are practically equal quantities. The circuit breaker must, therefore, be connected, not between the motor and the auto-starter, but between the latter and the source of supply. If the motor is to be started with full-load torque then the starting voltage should be not less than 70 per cent of full-line voltage, and the line starting current will be approximately three and one-half times the full-load current, with correspondingly greater currents flowing from auto-starter to motor.

Table I—Starting Current and Torque of Squirrel-Cage Motors

Voltage In Per Cent of Rated Voltage	Line Starting Current In Per Cent of Full-load Current	Starting Torque In Per Cent of Full-load Torque
40	112	32
60	250	72
80	450	128
100	700	200

Inasmuch as auto-starters are intended only for intermittent service, they are proportioned accordingly and are not intended to be left in circuit for an undue length of time. The maximum current drawn from the line in starting a motor by means of an auto-starter is a function of the rating and design of the apparatus in question, and of the voltage which is supplied at the motor terminals, and is practically independent of the load on which the motor is started. It is true that if the motor is started on a light load the starting current will fall away more quickly than with a heavy load, but the initial or maximum value of this current will, in all cases, be practically the same for any given voltage, and where large starting torque is required the corresponding current will be much in excess of the continuous carrying capacity of the motor. Manufacturers of auto-starters realizing this condition have in some cases equipped their devices so that the

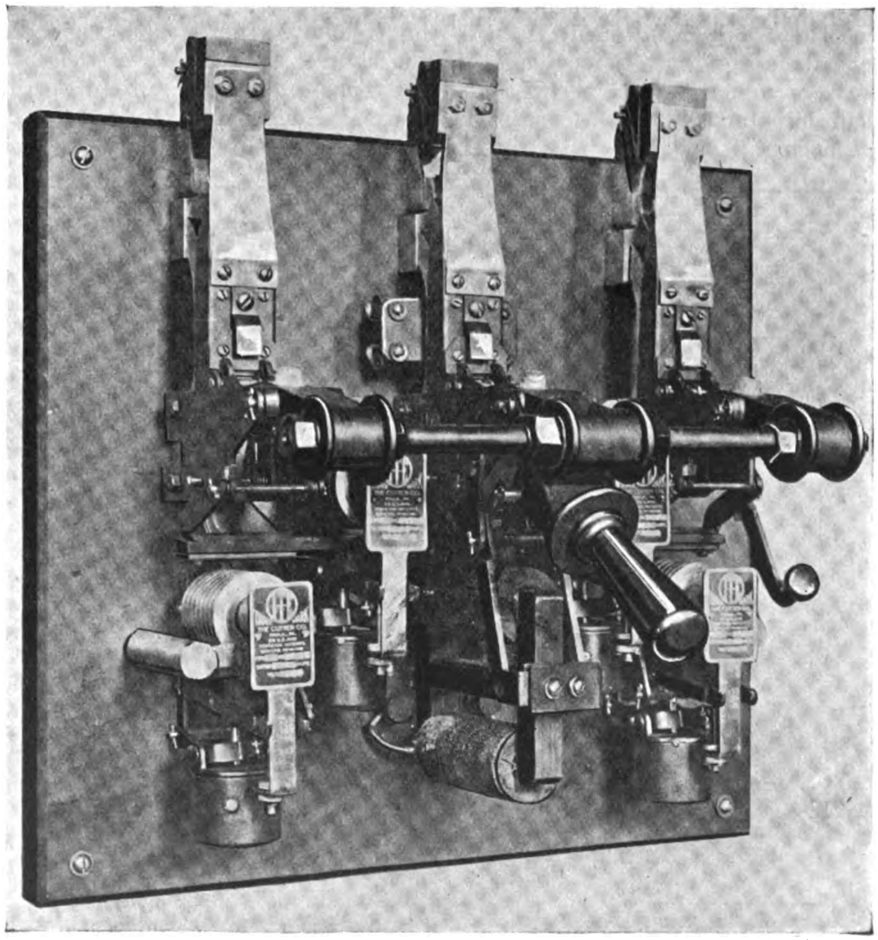


Fig. 1—A motor which is accelerated very gradually is protected by this breaker.

The breaker has two pairs of overload coils. One pair is connected in the starting leads of the compensator and the other pair in the line. The motor is slowly brought up to speed in several steps. If the controller is moved too fast the first pair of overload coils opens the breaker. This pair of coils has no time delay. The other pair which protects the motor under running conditions has inverse time delay.

circuit breaker may, if desired, be connected so that the overload features are effective only when the switch is in the running position.

The circuit breaker when so connected is, of course, not subject to the heavy starting current and the overload feature may, therefore, be set to operate at a current value determined only by running conditions. This method has on the other hand the disadvantage that it leaves the motor and the auto-starter without protection while the switch is in the starting position. The fact that the auto-starter is intended only for intermittent service suggests that this part of the equipment should be protected as well as the motor.

It is also obvious that the motor should be protected from undue continuance of heavy starting currents such as might result from attempts to start too heavily loaded, or with one phase disconnected. These combined requirements may be met in either of two ways. The first is by the employment of a time-limit circuit breaker so connected that the overload features will be in series with the motor both on starting and running. The characteristics of the time-limit circuit breaker are such that when set to open on moderate overloads long continued it will, nevertheless, permit the passage of heavier currents for a period sufficient for starting if load conditions are normal.

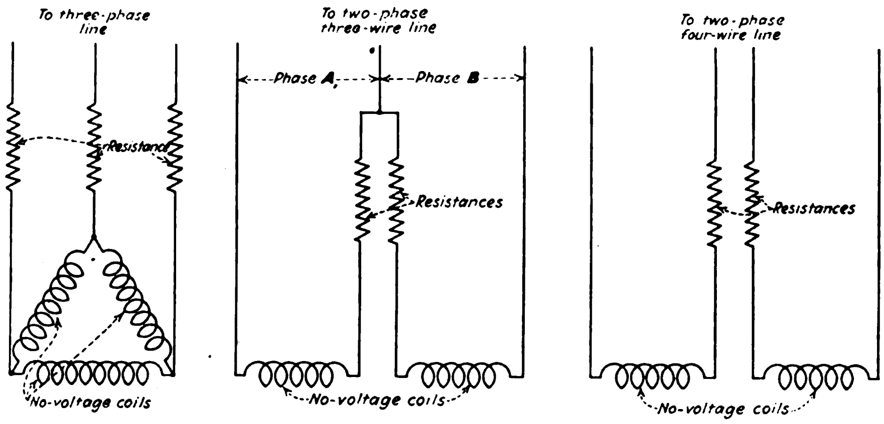


Fig. 3—Connections of no-voltage coils on polyphase circuits.
For a three-phase circuit breaker there must be three coils, while for a two-phase breaker two coils are required.

Obviously, with this arrangement the sensitiveness of the circuit breaker to overloads incident upon running is limited by the requirements of starting, and where motors are employed in connection with delicate mechanical operations it is sometimes desirable that the circuit breaker shall be responsive during running conditions to even the slightest overloads. To meet such contingencies a second method of protection may be used which involves the use of a special form of circuit breaker in which a single multi-polar switch member is under the control of two sets of overload coils, one set being in circuit on the starting side of the auto-starter, the other on the running side. In view of the fact already discussed, that the maximum instantaneous value of the starting current is practically independent of the load, it will at once be seen that the only protection possible during the starting period is not the limiting of the volume of this current, but the prevention of its undue continuance. Time limits are, therefore, essential adjuncts of the overload features connected on the starting side. They are also desirable on the running side unless the highest degree of sensitiveness to overload is required. Occasions sometimes arise, however, in which the character of the material handled or the nature of the operations performed is so delicate that the circuit breaker should operate instantly on the slightest increase in the load above a predetermined value. In this case the time-limit feature will not be required in conjunction with the running coils.

A modification of the foregoing case is presented where, in addition to the conditions already stated, the motor must be frequently stopped, and the starting must be accomplished gradually and with uniform acceleration in order to avoid injury to material in process. In such cases, where a motor of the squirrel-cage type is employed, the starting switch will be provided with a number of contacts, each connected with its respective taps from the auto-starter in such a way that the volt-

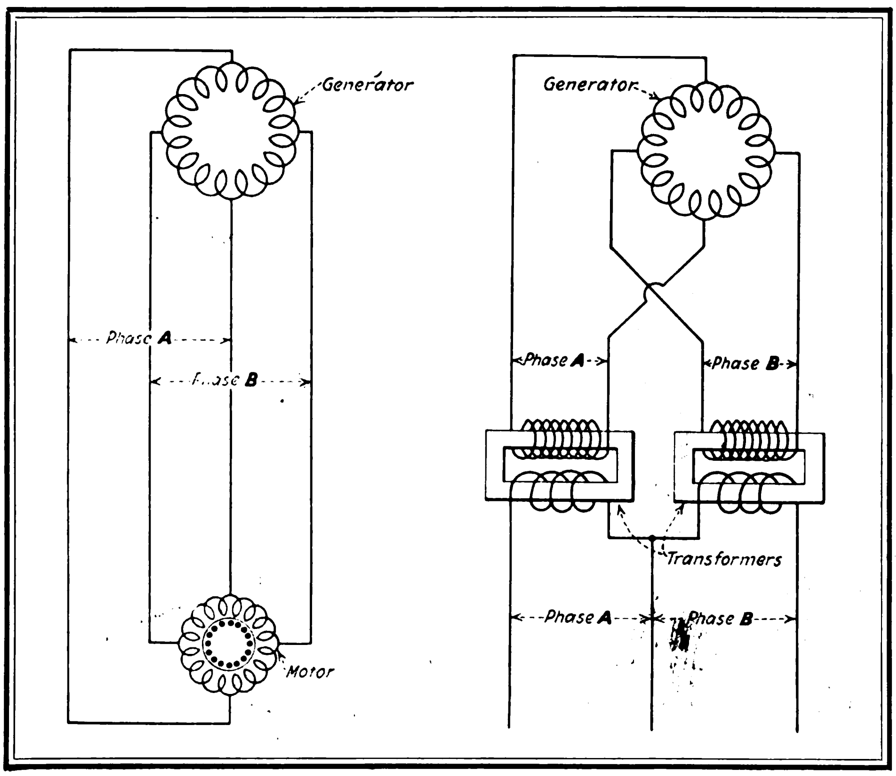


Fig. 2—Diagram showing when a three-pole breaker is necessary on a two-phase motor.
The drawing at the left illustrates a case where at least three poles are necessary in a circuit breaker. The phases of the two-phase motor are interconnected inside the motor while those of the generator are similarly interconnected. If only two poles were employed on the breaker voltage would still be impressed on the motor windings even after the breaker had opened. Two motors with interconnected phases and operating in parallel would likewise require three poles for each one. For three-wire, two-phase service as shown at the right a two-pole breaker usually suffices.

Table II—Starting Currents of Wound-Rotor Motors

These values are given by one manufacturer for 110-volt, three-phase, wound-rotor motors.

Horse-Power of Motor	Full Load Current, Amp.	Starting Current at 150 Per Cent of Full Load Torque, Amp.	Starting Current at Full Load Torque, Amp.
1	6.3	19	....
2	12	36	....
3	18	54	....
5	28	*42-84	28
10	54	70	54
15	81	120	81
20	112	167	112
30	168	252	168
50	268	400	268
75	390	585	390
100	550	825	550
150	780	1180	780

*The 5-hp. motor is made with or without starting switch.

age applied to the motor is increased by a number of successive steps, and if the switch is properly handled the motor will come up to speed gradually and with an even acceleration. If, however, the starting switch is moved forward too rapidly, the current will become excessive, and the circuit should be instantly opened. Fig. 1 illustrates a three-pole circuit breaker which is especially adapted to this class of service.

Affording Protection for Motors with Wound Rotors

There are two sets of over-load coils, one set connected on the starting side and the other set on the line side. In this instrument the time-limit feature should be omitted from the starting coils because unlike the case immediately preceding, the volume of starting current which passes through them is variable and depends upon the manner in which the starting switch is handled. If the handle is moved forward too quickly the breaker will open and thus prevent damage to the work.

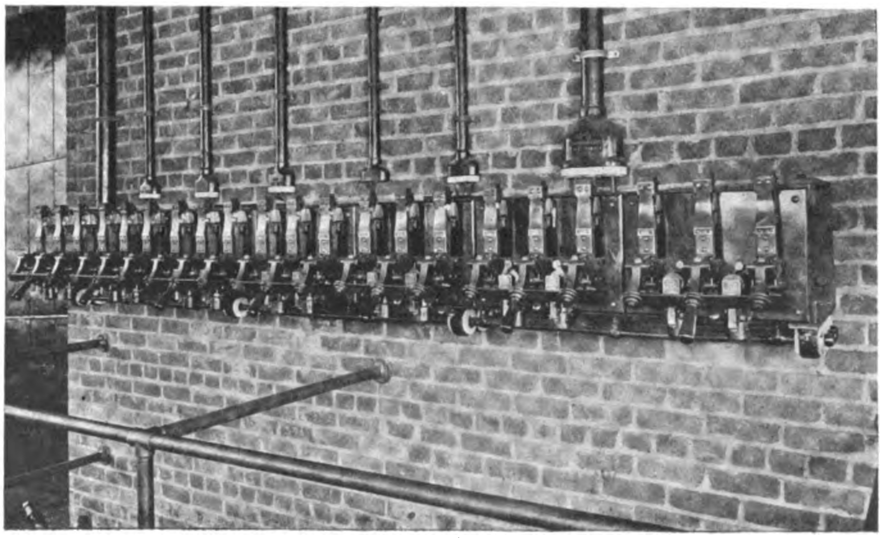
The foregoing discussion has dealt specifically with induction motors of the squirrel-cage type of armature and only casual reference has been made to the phase-wound type. This class of motor is characterized by a rotor having definite polar windings analogous to those of the primary. This form of motor is especially adapted for starting through resistance in the circuit of the rotor windings. The resistance is sometimes carried within the rotor and sometimes is external to it; in the latter case the rotor windings are connected with the starting switch through slip rings and brushes.

Usually for such a motor the circuit breaker which will give protection to the motor during running conditions will also protect it while it is being started. This is because the starting current is usually not greater than the full-load current. This is shown by Table II. This table relative to three-phase, 110-volt motors of the phase-wound type as supplied by a leading manufacturer, shows the relation between torque and starting current. While the figures given are for a specific voltage only, they show in a general way the ratios between the different quantities regardless of the operating voltage.

As may be seen from these figures, the current drawn on starting is directly proportional to the torque. With this type of motor the service performed by the machine driven by the motor will determine whether a time-limit feature is required or not.

Fig. 4—Three-pole circuit breakers on power feeders in the factory of the Hupp Motor Car Company.

These breakers protect three-phase feeder lines. They have an inverse-time overload feature. The individual motors supplied by lines branching from these, are protected by similar breakers.



How Many Poles Should the Circuit Breaker Have?

For three-phase, three-wire systems, three-pole circuit breakers are recommended as they afford means for completely disconnecting the motor from the system. Two-pole circuit breakers are, however, sometimes employed on the ground of economy. In either case, where the circuit breakers are of the overload type, there should not be less than two overload features in order that at least one of the two may be responsive to overload with any condition of circuit, balanced or unbalanced.

The conditions controlling the selection of circuit breakers for motors used on two-phase circuits demand fuller consideration. On two-phase, four-wire circuits, circuit breakers of at least three poles are required. This is because with circuit breakers of only two poles the motor may still be subjected to voltage if the motor has the two phases inter-connected in its windings, and in addition is supplied directly from a generator which has the two phases interconnected, or is operated in parallel with other motors which have the phases interconnected. This is illustrated in the left-hand drawing of Fig. 2. If a motor is operating under these conditions it will be subjected to a voltage of 0.7 times full voltage even though a two-pole circuit breaker has opened (one pole in each phase). The current to which a motor would be subjected under this condition would not sustain it in motion against a load and damage to the motor would probably result. Therefore, as the phases are often interconnected in the windings of two-phase motors, a circuit breaker of

Table III—Current per Kilowatt on Various A. C. Systems

This table shows the current per kilowatt at 100 per cent power factor. The values may also be used as approximate current per horsepower of induction-motor load assuming that the motors operate at about 86 per cent efficiency and 84 per cent power factor, which are reasonable values for motors over 5 hp., rated at least 860 r.p.m. and fully loaded.

Voltage	Amp. in Each Wire per Kw. Load at 100 Per Cent Power Factor				
	Two-Wire Single-Phase	Four-Wire Two-Phase	Three-Wire Two-Phase: Outside Wires	Three-Wire Two-Phase: Common Return	Three-Wire Three-Phase
110	9.1	4.5	4.5	6.43	5.25
220	4.55	2.27	2.27	3.21	2.62
330	3.03	1.51	1.51	2.14	1.75
440	2.27	1.13	1.13	1.60	1.31
550	1.82	.91	.91	1.29	1.05
1100	.91	.45	.45	.64	.53
2200	.46	.23	.23	.32	.26

at least three poles should be used. The fullest measure of protection will be secured by the use of four-pole breakers which, for reasons stated in the discussion relative to three-phase circuits, should be provided where protection against overloads is desired, with an overload coil in each of the two phases.

Sometimes where the two-phase system is supplied from transformers, a three-wire system of distribution is employed as shown in the right-hand side of Fig. 2. In this case the motor may be effectively protected from overload by the use of a two-pole instrument having two overload features. Unless the common main is grounded, however, a three-pole instrument is to be preferred, in which case the middle pole common to both phases should have a capacity 40 per cent in excess of that required for the outer poles, which each carry the current of one phase only.

All Poles Should Operate in Unison for Polyphase Circuits

Circuit breakers for the protection of all classes of polyphase motors should have the switch members rigidly united so that all poles will operate in unison both in opening and in closing. As the care of motor-driven machinery must often be placed in the hands of mechanics rather than trained electricians, it is highly important that the circuit breakers included in such equipments should be so designed that no possible method of handling them will defeat their protective operation. This requirement is admirably met by the circuit breaker which cannot be closed or held closed on overload. The construction of the breaker is such that when it operates on overload the switch arm is instantly released from the controlling lever, and the circuit is broken regardless of any pressure which may be exerted upon the handle. The usual hand switch may be omitted where this type of breaker is employed, as the instrument combines in itself the functions of both switch and circuit breaker.

The Breaker Should Open on Failure of Voltage

With the majority of polyphase motors a starting switch is employed in order to reduce the starting current, which would otherwise attain excessive magnitude. If the power supply should fail the motor should be automatically disconnected from the line. Should it remain in circuit it will be subjected to heavy currents when the line is again charged. This form of suddenly applied overload is likely to prove injurious to the motor, but especially so to the machinery which it drives.

Against such contingencies the motor can be properly protected by the use of a no-voltage attachment on the circuit breaker. The no-voltage device should be so constructed that it is automatically thrown into action by the closing of the breaker. The design should be such that there is no vibration of the armature. There should be a coil in each phase for polyphase motors, as shown in Fig. 3. This will result in a steady and strong magnetism for holding the armature. The stronger holding force allows the use of a strong spring for forcing the armature against the trigger when the armature is released.

The internal characteristics of many polyphase motors are such that after having been started from the polyphase circuit they will, if but lightly loaded, continue to run single-phase in the event of interruption of one main of the circuit, and when so running will sustain approximately normal voltage on the motor side of the disconnected main. Under such circumstances, therefore, the no-voltage feature will not respond. This condition is taken care of by the employment of circuit breakers combining both overload and no-voltage features.

Requirements of Protection for Power Feeders

A two-wire feeder circuit may be afforded protection during running conditions by the use of a single-pole circuit breaker which, if either main of the circuit be permanently grounded, must be installed in the ungrounded main. The term "running conditions" is used here in order to distinguish between the conditions which obtain while the feeder is actually supplying the power, and those which may exist at the moment the line is being connected into circuit at the switchboard. In the first mentioned instance, the circuit breaker is free to respond should the load become excessive, while in the second instance, if a single-pole circuit breaker of ordinary construction is made use of as the means of finally closing the feeder circuit, its ability to respond to such overload as may occur at the instant of closing is seriously impaired by the pressure exerted by the hand of the operator.

This has led to the practice of employing a hand switch in series with the circuit breaker, the method of operation being to open the hand switch before closing the circuit breaker, finally completing the circuit by closing the hand switch. Where this method is rigidly followed a single-pole circuit breaker may be relied upon to give protection not only under running conditions, but also while the feeder is being brought into circuit. Through haste or ignorance, however, it frequently happens that the operator will close the circuit breaker without first opening the hand switch. Such action is particularly likely after the circuit breaker has opened upon overload, and if attempted while the condition which gave rise to the overload still exists, damage is almost certain to result.

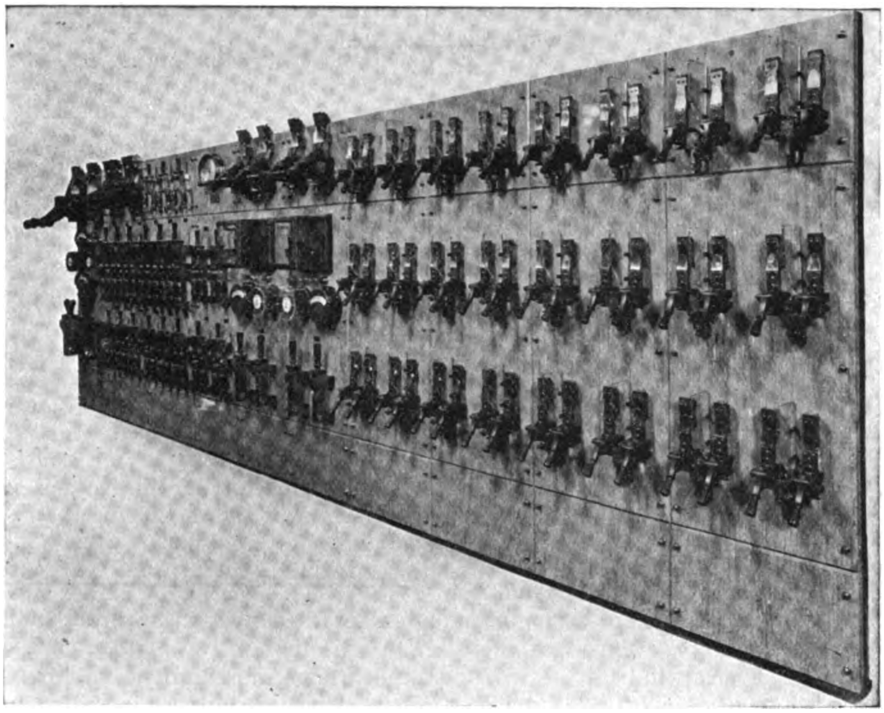


Fig. 5—Main and feeder circuit breakers on a switchboard.

The large breakers at the left of the board are on the main service panels. The breakers at the right control the feeder circuits.

These considerations make desirable the use of protective apparatus whose operation will be independent of the manner in which it is handled by the switchboard attendant, and have led to the development of two distinct types of circuit breakers, each of which admirably fulfills these conditions and renders the hand switch superfluous.

The first of these is the breaker with two members which are closed independently of each other. One member is closed and then the other. If there is a short circuit on the line the first member is free to open when the second is being closed.

The other type of circuit breaker which is suitable for a two-wire feeder is the one which is non-closable on overload. If an overload is present when the breaker is closed it will open at normal speed regardless of the pressure on the handle.

Conditions Determining Use of "Time-Limit" on Feeders

Circuit breaker equipment should be chosen so as to give the full measure of protection without occasioning unnecessary interruption in the service. Short-circuit currents such as may result from accidental crosses or from defects in insulation reach a magnitude not generally appreciated, and the same may also be said of currents frequently arising through improper handling of apparatus, or as the result of defects in the apparatus itself. While such currents, especially when superimposed upon normal load currents of considerable volume, are likely to exceed the capacity of the feeders, it is not always desirable that the feeder circuit breakers should open and thus disconnect other branch circuits in which the conditions are normal. To meet such contingencies, therefore, it is recommended that both light and power feeders be protected with time-limit circuit breakers, and that the various sub-divisions of the circuit be also protected by circuit breakers of smaller capacity installed at the centers of distribution. In the case of motors, each should be protected by its individual circuit breaker. Where this method is followed, only the portion of the circuit in which the trouble arises will be disconnected and the feeder breakers will operate only in the event of sustained overloads.

Factors in Protection of Three-Wire Feeders

The points just covered as to the use of time-limit circuit breakers and the protection of branch circuits, apply to three-wire circuits with the same force as they do to two-wire circuits. On three-wire lighting feeders in order to avoid excess voltage on lamps as the result of unbalanced load, it is essential that the neutral main shall not be opened unless at least one of the mains is already open or is opened at the same time. It is also desirable that the two main leads of the circuit shall be opened or closed together, as otherwise the neutral and compensators might be unduly loaded.

With these facts in view it will be seen that the circuit breaker should have at least two poles, that these should be connected into the two main leads and that they should be rigidly united in order to secure their simultaneous action both in opening and closing. As the load in each of these two leads is not necessarily the same, each of the two poles should be provided with an overload coil, and the breaker should be non-closable on a definite overload.

Use of this instrument meets the protective requirements of the average lighting feeder on which the conditions of service are such that extensive unbalancing of the load is improbable. However, on lighting feeders in which serious unbalancing is likely to occur, likewise on power feeders, the circuit breaker should be provided with a third overload feature for connection into the neutral main. The object of the third overload device is to limit the neutral current to the safe carrying capacity of the compensating devices. This class of instrument, more particularly when equipped with time-limit features, meets every requirement of three-wire feeder protection. The use of the third or neutral overload feature is especially desirable where the unbalanced load is taken care of by a compensator whose capacity is small in comparison with that of the main generators. Where it is not desired to interrupt the neutral main, the center switch member may be omitted, the corresponding overload feature being retained, as it is highly important that the compensator be kept in service. To this end the unbalanced load must be prevented from attaining excessive values in any of the various sections of the circuit in which they may arise.

There still remains the possibility of the cumulative effect of the unbalanced current in several feeders being sufficient to overtax the capacity of the compensator. Whether or not this danger is sufficient to warrant the installation of protective devices directly in the circuit of the compensator, is a matter to be decided in accordance with the service conditions. (Continued on page 601)

Handy Tables For Use in

Laying Out Wave Windings for A.C. Rotors

Having 120-deg. Spacing Between Line Leads Together With Instructions for Calculating Wave Windings for Machines in Which the Number of Slots Is Not a Multiple of the Number of Poles

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THIS IS the last of a series of articles on alternating-current, wave windings. The first three articles, which were published in the September, October, and November issues, explained how to lay out and construct stator wave windings and also gave short-cut methods and tabulations of data for use in laying out this type of winding. This article gives similar tabulations for use on rotor windings and also discusses how to lay out wave windings for machines in which the number of slots is not a multiple of the number of poles.

PREVIOUS articles in the September, October and November issues explained how to lay out and construct wave windings for alternating-current motors. Tables and short-cut methods have also been given which will greatly shorten the time and effort in accomplishing this work. We will now discuss wave windings having a spacing of 120 deg. between the line leads.

Tables I to V give the data for three-phase rotor or stator windings having a spacing of 120 deg. between the line leads. This type of connection is used principally on rotors; consequently, only the three-phase star and delta connecting data are given.

These tables are worked up in a manner similar to those that have been described in the November issue. The only difference is in locating the leads, for these tables give the winding data for windings having 120-deg. lead spacing instead of having the line leads placed as close together as possible. The starting lead of the A phase will of course be located in slot *1* and the starting lead of the B and C phases will be spaced 120 deg. each way from the starting lead of the A phase. For example, in a ninety-six-slot machine, the leads would be spaced $96 \div 3 = 32$ slots apart. Then if the A phase starts in slot *1*, the B phase would start in $1 + 32 =$ slot *33*, and the C phase would start in $33 + 32 =$ slot *65*.

Dividing the total number of slots by 3, to obtain the 120-deg. spacing will not hold true of windings for six, twelve, eighteen, twenty-four, etc., poles. To show the method of locating the 120-deg. spacing for these windings, we will locate the leads for a six-pole, three-phase winding having seventy-two slots and coils. There will be $72 \div 6 = 12$ slots per pole and $12 \div 3 = 4$ slots per pole per phase. We will start the A_1 lead in slot *1* and since the winding is retrogressive, the three remaining slots of that pole-phase group will fall in slots *72, 71* and *70*. This is the first pole-phase group of the first pole. The second pole-phase group will fall in slots *2, 3, 4* and *5* and the third pole-phase group will fall in slots *6, 7, 8* and *9*. These three groups make up the first pole. Let us lay them out as is shown in Fig. 1. We will indicate the polarity of this pole by the arrow pointing up. The other poles are laid out in a similar manner as is shown in Fig. 1. Adjacent poles are of opposite polarity as is indicated by the arrows placed at the end of each pole group.

To have exactly 120-deg. spacing between the leads, there would be $72 \div 3 = 24$ slots between each pair of leads; that is, the leads would fall in slots *1, 25* and *49*. As was said before, we will start the A_1 lead in slot *1* as is marked in the first pole-phase group in Fig. 1. This reserves the first pole-phase group of the first pole and of the succeeding poles for the A phase. For 120-deg. spacing, the B-phase starting lead should fall in slot *25*. Slot *25* falls in the first pole-phase group of the third pole. This pole-phase group was reserved for the A phase, when we placed the

First Pole (70, 71, 72, 1*) (2, 3, 4, 5) (6, 7, 8, 9) ↑ — A_1 at slot 1
Second Pole (10, 11, 12, 13) (14, 15, 16, 17) (18, 19, 20, 21) ↓
Third Pole (22, 23, 24, 25*) (26, 27, 28, 29) (30, 31, 32, 33) ↑ — B_1 at slot 29
Fourth Pole (34, 35, 36, 37) (38, 39, 40, 41) (42, 43, 44, 45) ↓ — C_1 at slot 45
Fifth Pole (46, 47, 48, 49*) (50, 51, 52, 53) (54, 55, 56, 57) ↑
Sixth Pole (58, 59, 60, 61) (62, 63, 64, 65) (66, 67, 68, 69) ↓

Winding to have 6 poles, 72 slots
* = Location of slots having 120-degree spacing
Arrows indicate polarity of poles

Fig. 1—Method of locating slots for starting leads of each phase for windings of six, twelve, eighteen, etc., poles when 120-deg. lead spacing is desired.

The A phase is started in slot *1*, thereby reserving the left-hand pole-phase group in each pole for the A phase. For exactly 120-deg. spacing, the B phase would start in slot 25. This slot is in an A pole-phase group, so slot 29 is selected for the B-phase starting lead. To have exactly 120-deg. spacing the C phase would start in slot 49. This slot is in a pole-phase group reserved for the A phase and has the same polarity (indicated by arrows at right) as the poles in which the other starting leads are located. Hence, the starting lead for the C phase is located in slot 45 which has the correct polarity and is in a pole-phase group that is not used by the A or B phases.

starting lead of the A phase in slot *1*; consequently, slot *25* cannot be used for the B_1 lead. However, slot *29* is available and falls in the second pole-phase group; therefore, we will use slot *29* in which to start the B_1 lead. We have said before that the instantaneous polarity of two phases must be the same while the third one is opposite. The A and B phases are to have the same instantaneous polarity. The first and third poles have the same instantaneous polarity; therefore, slot *29* will be suitable for the B phase from this point of view.

For 120-deg. spacing, the starting lead of the C phase would fall in slot *49*. Slot *49* falls in an A-phase, pole-phase group as is shown in fifth pole of Fig. 2, and has the same polarity as the other poles in which the two other phases were started. Therefore, slot *49* cannot be used to start the B_1 lead. However, slot *45* falls in a pole of the opposite polarity and also falls in a pole-phase group that is not reserved for either the A or B phases. We will start the C_1 lead in slot *45*.

Table I—Four-Pole, Three-Phase Windings

Having 120-Deg. Spacing Between Line Leads

These tables give the arrangement for a series-star connection. To obtain a series-delta connection, connect A and C_1 to one line, B and A_1 to the second line and C and B_1 to the third line.
For a left-hand winding number slots in a clockwise direction.
For a right-hand winding number slots in a counter-clockwise direction.
"Top" refers to top conductor in slot; "bottom" refers to bottom conductor in slot.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top A	Leads Top B	Leads Top C	Star Top A_1	Star Top B_1	Star Top C_1	Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top					
24	4	2	1 & 7	1	9	17	19	3	11	(12- 18) (20-2) (4-10)	(19-24)	(13-18)	(3-8)	(21-2)	(11-16)	(5-10)
36	6	3	1 & 10	1	13	25	28	4	16	(17- 26) (29-2) (5-14)	(27- 35, 28- 36)	(18- 26, 19- 27)	(3-11, 4-12)	(30-2, 31- 3)	(15- 23, 16- 24)	(6-14, 7-15)
48	8	4	1 & 13	1	17	33	37	5	21	(22- 34) (38-2) (6-18)	(35- 46, 37- 48)	(23- 34, 25- 36)	(3-14, 5-16)	(39-2, 41- 4)	(19- 30, 21- 32)	(7-18, 9-20)
60	10	5	1 & 16	1	21	41	46	6	26	(27- 42) (47-2) (7-22)	(43- 57, 46- 60)	(28- 42, 31- 45)	(3-17, 6-20)	(48-2, 51- 5)	(23- 37, 26- 40)	(8-22, 11-25)
72	12	6	1 & 19	1	25	49	55	7	31	(32- 50) (56-2) (8-26)	(51- 68, 55- 72)	(33- 50, 37- 54)	(3-20, 7-24)	(57-2, 61- 6)	(27- 44, 31- 48)	(9-26, 13-30)
84	14	7	1 & 22	1	29	57	64	8	36	(37- 58) (65-2) (9-30)	(59- 79, 64- 84)	(38- 58, 43- 63)	(3-23, 8-28)	(66-2, 71- 7)	(31- 51, 36- 56)	(10-30, 15-35)
96	16	8	1 & 25	1	33	65	73	9	41	(42- 66) (74-2) (10-34)	(67- 90, 73- 96)	(43- 66, 49- 72)	(3-26, 9-32)	(75-2, 81- 8)	(35- 58, 41- 64)	(11-34, 17-40)
108	18	9	1 & 28	1	37	73	82	10	46	(47- 74) (83-2) (11-38)	(75-101, 82-108)	(48- 74, 55- 81)	(3-29 10-36)	(84-2, 91- 9)	(39- 65, 46- 72)	(12-38, 19-45)
120	20	10	1 & 31	1	41	81	91	11	51	(52- 82) (92-2) (12-42)	(83-112, 91-120)	(53- 82, 61- 90)	(3-32, 11-40)	(93-2, 101-10)	(43- 72 51- 80)	(13-42, 21-50)
132	22	11	1 & 34	1	45	89	100	12	56	(57- 90) (101-2) (13-46)	(91-123, 100-132)	(58- 90, 67- 99)	(3-35, 12-44)	(102-2, 111-11)	(47- 79, 56- 88)	(14-46, 23-55)
144	24	12	1 & 37	1	49	97	109	13	61	(62- 98) (110-2) (14-50)	(99-134, 109-144)	(63- 98, 73-108)	(3-38, 13-48)	(111-2, 121-12)	(51- 86 61- 96)	(15-50, 25-60)
156	26	13	1 & 40	1	53	105	118	14	66	(67-106) (119-2) (15-54)	(107-145, 118-156)	(68-106, 79-117)	(3-41, 14-52)	(120-2, 131-13)	(55- 93, 66-104)	(16-54, 27-65)
168	28	14	1 & 43	1	57	123	127	15	71	(72-114) (128-2) (16-58)	(115-156, 127-168)	(73-114, 85-126)	(3-44, 15-56)	(129-2, 141-14)	(59-100, 71-112)	(17-58, 29-70)
180	30	15	1 & 46	1	61	131	136	16	76	(77-122) (137-2) (17-62)	(123-167, 136-180)	(78-122, 91-135)	(3-47, 16-60)	(138-2, 151-15)	(63-107, 76-120)	(18-62, 31-75)
192	32	16	1 & 49	1	65	139	145	17	81	(82-130) (146-2) (18-66)	(131-178, 145-192)	(83-130, 97-144)	(3-50, 17-64)	(147-2, 161-16)	(67-114, 81-128)	(19-66, 33-80)
204	34	17	1 & 52	1	69	147	154	18	86	(87-138) (155-2) (19-70)	(139-189, 154-204)	(88-138, 103-153)	(3-53, 18-68)	(156-2, 171-17)	(71-121, 86-136)	(20-70, 35-85)
216	36	18	1 & 55	1	73	155	163	19	91	(92-146) (164-2) (20-74)	(147-200, 163-216)	(93-146, 109-162)	(3-56, 19-72)	(165-2, 181-18)	(75-128, 91-144)	(21-74, 37-90)

Table II—Six-Pole, Three-Phase Windings

Having 120-Deg. Spacing Between Line Leads
See heading of Table I for instructions on using table.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top A	Leads Top B	Leads Top C	Star Top A_1	Star Top B_1	Star Top C_1	Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top					
36	6	2	1 & 7	1	15	23	31	9	17	(24- 30) (2- 8) (10-16)	(31-36)	(25-30)	(9-14)	(3-8)	(17-22)	(11-16)
54	9	3	1 & 10	1	22	34	46	13	25	(35- 44) (2-11) (14-23)	(45- 53, 46- 54)	(36- 44, 37- 45)	(12-20, 13-21)	(3-11, 4-12)	(24- 32, 25- 33)	(15-23, 16-24)
72	12	4	1 & 13	1	29	45	61	17	33	(46- 58) (2-14) (18-30)	(59- 70, 61- 72)	(47- 58, 49- 60)	(15-26, 17-28)	(3-14, 5-16)	(31- 42, 33- 44)	(19-30, 21-32)
90	15	5	1 & 16	1	36	56	76	21	41	(57- 72) (2-17) (22-37)	(73- 87, 76- 90)	(58- 72, 61- 75)	(18-32, 21-35)	(3-17, 6-20)	(38- 52, 41- 55)	(23-37, 26-40)
108	18	6	1 & 19	1	43	67	91	25	49	(68- 86) (2-20) (26-44)	(87-104, 91-108)	(69- 86 73- 90)	(21-38, 25-42)	(3-20, 7-24)	(45- 62 49- 66)	(27-44, 31-48)
126	21	7	1 & 22	1	50	78	106	29	57	(79-100) (2-23) (30-51)	(101-121, 106-126)	(80-100, 85-105)	(24-44, 29-49)	(3-23, 8-28)	(52- 72, 57- 77)	(31-51, 36-56)
144	24	8	1 & 25	1	57	89	121	33	65	(90-114) (2-26) (34-58)	(115-138, 121-144)	(91-114, 97-120)	(27-50, 33-56)	(3-26 9-32)	(59- 82, 65- 88)	(35-58, 41-64)
162	27	9	1 & 28	1	64	100	136	37	73	(101-128) (2-29) (38-65)	(129-155, 136-162)	(102-128, 109-135)	(30-56, 37-63)	(3-29, 10-36)	(66- 92, 73- 99)	(39-65, 46-72)
180	30	10	1 & 31	1	71	111	151	41	81	(112-142) (2-32) (42-72)	(143-172 151-180)	(123-142, 121-150)	(33-62, 41-70)	(3-32, 11-40)	(73-102, 81-110)	(43-72, 51-80)
198	33	11	1 & 34	1	78	122	166	45	89	(123-156) (2-35) (46-79)	(157-189, 166-198)	(134-156, 133-165)	(36-68, 45-77)	(3-35, 12-44)	(80-112, 89-121)	(47-79, 56-88)
216	36	12	1 & 37	1	85	133	181	49	97	(134-170) (2-38) (50-86)	(171-206, 181-216)	(145-170, 145-180)	(39-74, 49-84)	(3-38, 13-48)	(87-122, 97-132)	(51-86, 61-96)

Table III—Eight-Pole, Three-Phase Windings

Having 120-Deg. Spacing Between Line Leads
See heading of Table I for instructions on using table.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top A	Leads Top B	Leads Top C	Star Top A_1	Star Top B_1	Star Top C_1	Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top					
24	4	1	1 & 4	1	17	9	22	14	6	(19- 22)(11- 14)(3- 6)	None					
48	8	2	1 & 7	1	33	17	43	27	11	(36- 42)(20- 26)(4-10)	(43-48)	(37-42)	(27-32)	(21-26)	(11-16)	(5-10)
72	12	3	1 & 10	1	49	25	64	40	16	(53- 62)(29- 38)(5-14)	(63- 71, 64- 72)	(54- 62, 55- 63)	(39- 47, 40- 48)	(30- 38, 31- 39)	(15-23, 16-24)	(6-14, 7-15)
96	16	4	1 & 13	1	65	33	85	53	21	(70- 82)(38- 50)(6-18)	(83- 94, 85- 96)	(71- 82, 73- 84)	(51- 62, 53- 64)	(39- 50, 41- 52)	(19-30, 21-32)	(7-18, 9-20)
120	20	5	1 & 16	1	81	41	106	66	26	(87-102)(47- 62)(7-22)	(103-117, 106-120)	(88-102, 91-105)	(63- 77, 66- 80)	(48- 62, 51- 65)	(23-37, 26-40)	(8-22, 11-25)
144	24	6	1 & 19	1	97	49	127	79	31	(104-122)(56- 74)(8-26)	(123-140, 127-144)	(105-122, 109-126)	(75- 92, 79- 96)	(57- 74, 61- 78)	(27-44, 31-48)	(9-26, 13-30)
168	28	7	1 & 22	1	113	57	148	92	36	(121-142)(65- 86)(9-30)	(143-163, 148-168)	(122-142, 127-147)	(87-107, 92-112)	(66- 86, 71- 91)	(31-51, 36-56)	(10-30, 15-35)
192	32	8	1 & 25	1	129	65	169	105	41	(138-162)(74- 98)(10-34)	(163-186, 169-192)	(139-162, 145-168)	(99-122, 105-128)	(75- 98, 81-104)	(35-58, 41-64)	(11-34, 17-40)
216	36	9	1 & 28	1	145	73	190	118	46	(155-182)(83-110)(11-38)	(183-209, 190-216)	(156-182, 163-189)	(111-137, 118-144)	(84-110, 91-117)	(39-65, 46-72)	(12-38, 19-45)
240	40	10	1 & 31	1	161	81	211	131	51	(172-202)(92-122)(12-42)	(203-232, 211-240)	(173-202, 181-210)	(123-152, 131-160)	(93-122, 101-130)	(43-72, 51-80)	(13-42, 21-50)

So far we have discussed wave windings that have an equal number of coils in each section. Some wave windings will be found that have an equal number of coils in each phase but an unequal number of coils in each section. For example, consider an eighty-four-slot stator wound with a two-layer, left-hand, retrogressive, wave winding having eight poles and eighty-four coils connected series star. In this winding, there will be $84 \div 3 = 28$ coils per phase. Since the number of sections is equal to twice the number of phases, the number of coils per section will equal $84 \div 6 = 14$ coils per section. In a wave winding, the coils per section must be a multiple of the number of pairs of poles; that is, a section must start and finish in a pole-phase group belonging to the same phase and located in an adjacent pole. In this case the number of coils per section is not a multiple of the pairs of poles, for the coils per section equal $84 \div 6 = 14$, and the pairs of poles equal $8 \div 2 = 4$ and $14 \div 4 = 3\frac{1}{2}$. A section with this layout would encircle the stator three and one-half times and would not finish in a pole-phase group of an adjacent pole and which corresponded with the pole-phase group of the starting lead.

To lay out a winding for this combination of poles and slots, first divide the winding so that there will be an equal number of coils per phase; that is, $84 \div 3 = 28$ coils per phase. Then divide the coils per phase by the number of pairs of poles, in this case $28 \div 4 = 7$, which means that to pick up the twenty-eight coils in one phase, the winding must be encircled seven times. Since each phase is divided into two sections, we will divide the encircling number by two; that is, $7 \div 2 = 3$ with a remainder of 1, or $4+3=7$. Therefore, to pick up twenty-eight coils per phase and at the same time to encircle the winding seven times in doing so, one section of the phase must contain $3 \times 4 = 12$ coils and the other section must contain $4 \times 4 = 16$ coils.

The winding pitch equals the total number of slots divided by half the number of poles equals $84 \div 4 = 21$, or a pitch of 1-and-22. Hence, the front and back pitches will be unequal as $21 \div 2 = 10\frac{1}{2}$. Make the back pitch equal to 11, or a pitch of 1-and-12 and the front pitch equal to 10, or a pitch of 1-and-11. Using the front and back pitch as calculated, lay out the first section of sixteen coils in the manner shown at *M* of Fig. 2. Likewise, lay out the second section of this phase as is shown at *N* in Fig. 2.

The next step is to check the phase-belt overlapping. With this type of winding, there will be a number of slots in which the top and bottom coil halves will belong to different phases. It will be necessary to locate these slots and also to determine to which phases the various coil sides belong. Let us start with the first slot number in the first section of the A phase. This is shown at *M* of Fig. 2. As determined before, we have found that the winding is encircled seven times to pick up all the coils of one phase. We also decided that the winding was to be encircled four times to pick up the coils of the first section and encircled three times to pick up the coils of the second section; that is, $4 + 3 = 7$, which is the total number of times the winding is encircled to pick up all the coils of one phase. Now, since the winding is retrogressive and is encircled four times in picking up the coils of the first section, a pole-phase group will contain four slots and these slots will be *1*, *84*, *83* and *82*. The A phase starts in slot *1*; that is the reason that we have picked out slot *1* and the winding being retrogressive, it would naturally follow that slots *84*, *83* and *82* would be the other slots of that pole-phase group. We will now lay out the slots in order as is shown at the bottom of Fig. 2, beginning with slot *82* and following consecutively through all the slots of the machine. Now, check through the first section as shown at *M* of Fig. 2 to see whether slots *1*

Table IV—Ten-Pole, Three-Phase Windings

Having 120-Deg. Spacing Between Line Leads
See heading of Table I for instructions on using table.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top			Star Top			Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top
				A	B	C	A_1	B_1	C_1		
30	5	1	1 & 4	1	11	21	28	8	18	(25- 28)(5- 8)(15- 18)	None
60	10	2	1 & 7	1	21	41	55	15	35	(48- 54)(8-14)(28- 34)	(55-60) (49-54) (15-20) (9-14) (35-40) (29-34)
90	15	3	1 & 10	1	31	61	82	22	52	(71- 80)(11-20)(41- 50)	(81- 89, 82- 90)(72- 80, 73- 81)(21-29, 22-30)(12-20, 13-21)(51- 59, 52- 60)(42- 50, 43- 51)
120	20	4	1 & 13	1	41	81	109	29	69	(94-106)(14-26)(54- 66)	(107-118, 109-120)(95-106, 97-108)(27-38, 29-40)(15-26, 17-28)(67- 78, 69- 80)(55- 66, 57- 68)
150	25	5	1 & 16	1	51	101	136	36	86	(117-132)(17-32)(67- 82)	(133-147, 136-150)(118-132, 121-135)(33-47, 36-50)(18-32, 21-35)(83- 97, 86-100)(68- 82, 71- 85)
180	30	6	1 & 19	1	61	121	163	43	103	(140-158)(20-38)(80- 98)	(159-176, 163-180)(141-158, 145-162)(39-56, 43-60)(21-38, 25-42)(99-116, 103-120)(81- 98, 85-102)
210	35	7	1 & 22	1	71	141	190	50	120	(163-184)(23-44)(93-114)	(185-205, 190-210)(164-184, 169-189)(45-65, 50-70)(24-44, 29-49)(215-135, 120-140)(94-114, 99-119)
240	40	8	1 & 25	1	81	161	217	57	137	(186-210)(26-50)(106-130)	(211-234, 217-240)(187-210, 193-216)(51-74, 57-80)(27-50, 33-56)(231-154, 137-160)(107-130, 113-136)

Table V—Twelve-Pole, Three-Phase Windings

Having 120-Deg. Spacing Between Line Leads
See heading of Table I for instructions on using table.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top			Star Top			Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top
				A	B	C	A_1	B_1	C_1		
36	6	1	1 & 4	1	14	30	34	11	27	(31- 34)(8-11)(24- 27)	None
72	12	2	1 & 7	1	27	59	67	21	53	(60- 66)(14-20)(46- 52)	(67-72) (61-66) (21-26) (15-20) (53-58) (47-52)
108	18	3	1 & 10	1	40	88	100	31	79	(89- 98)(20-29)(68- 77)	(99-107, 100-108)(90- 98, 91- 99)(30-38, 31-39)(21-29, 22-30)(78- 86, 79- 87)(69- 77, 70- 78)
144	24	4	1 & 13	1	53	117	133	41	105	(118-130)(26-38)(90-102)	(131-142, 133-144)(119-130, 121-132)(39-50, 41-52)(27-38, 29-40)(103-114, 105-116)(91-102, 93-104)
180	30	5	1 & 16	1	66	146	166	51	131	(147-162)(32-47)(112-127)	(163-177, 166-180)(148-162, 151-165)(48-62, 51-65)(33-47, 36-50)(128-142, 131-145)(113-127, 116-130)
216	36	6	1 & 19	1	79	175	199	61	157	(176-194)(38-56)(134-152)	(195-212, 199-216)(177-194, 181-198)(57-74, 61-78)(39-56, 43-60)(153-170, 157-174)(135-152, 139-156)
252	42	7	1 & 22	1	92	204	132	71	183	(205-226)(44-65)(156-177)	(227-247, 232-252)(206-222, 211-231)(66-86, 71-91)(45-65, 50-70)(178-198, 183-203)(157-187, 162-182)

84, 83 and *82* are occupied by any of the first section coils. In the coils shown at *M* of Fig. 2, the left-hand coil side falls in the top of the slot and the right-hand coil side falls in the bottom of the slot. In checking through the first section shown at *M* of Fig. 2, we find that the top conductors in slots *1, 84, 83* and *82* are used by this section. In checking through the second section, we find that the second section uses the bottom conductors in slots *1, 84* and *83*, and that the bottom conductor in slot *82* is left open to be used by some other phase. We will draw a horizontal line above those slots in which both conductors are used by the same phase as is shown at *A* in the diagram at the bottom of Fig. 2. The A phase uses only the top conductor in slot *82;* therefore, we will draw a diagonal line in the direction shown to indicate this fact. If a bottom coil had been used in this slot by this phase, the diagonal line would have been drawn at right angles to this one.

We will now treat the second slot number of the first section in a similar manner. The second slot number of the first section is slot *12*. The other three slots of this pole-phase group are *11, 10* and *9*. Checking through the first and second sections of the A phase as shown at *M* and at *N* of Fig. 2, we find that the first section uses the bottom conductors in all four slots and that the second section uses the top conductor in slots *9, 10* and *11*. We mark a horizontal line above slots *9, 10* and *11* and a diagonal line through slot *12* in the small diagram shown at the bottom of Fig. 2. Check the remaining slots of the first series of coils in the same manner. This will locate all of the A pole-phase groups.

Since the line leads are to have 120-deg. spacing and since the A phase starts in slot *1*, the B phase will start in slot $(84 \div 3) + 1 =$ slot *29* and the C phase will start in $29 + 28 =$ slot *57*.

Lay out the B and C phases in the same manner as the A phase is shown at *M* and *N*. This is done in *O, P, Q,* and *R* of Fig. 2. Starting at slot *29* for the C phase we check through the winding in the same manner as was done for the A phase and locate the phase-overlapping belt. The same is done for the B phase starting with slot *57*.

This type of winding can be connected only in series, for the coils per section are not equal and if the coils were paralleled circulating currents would be set up.

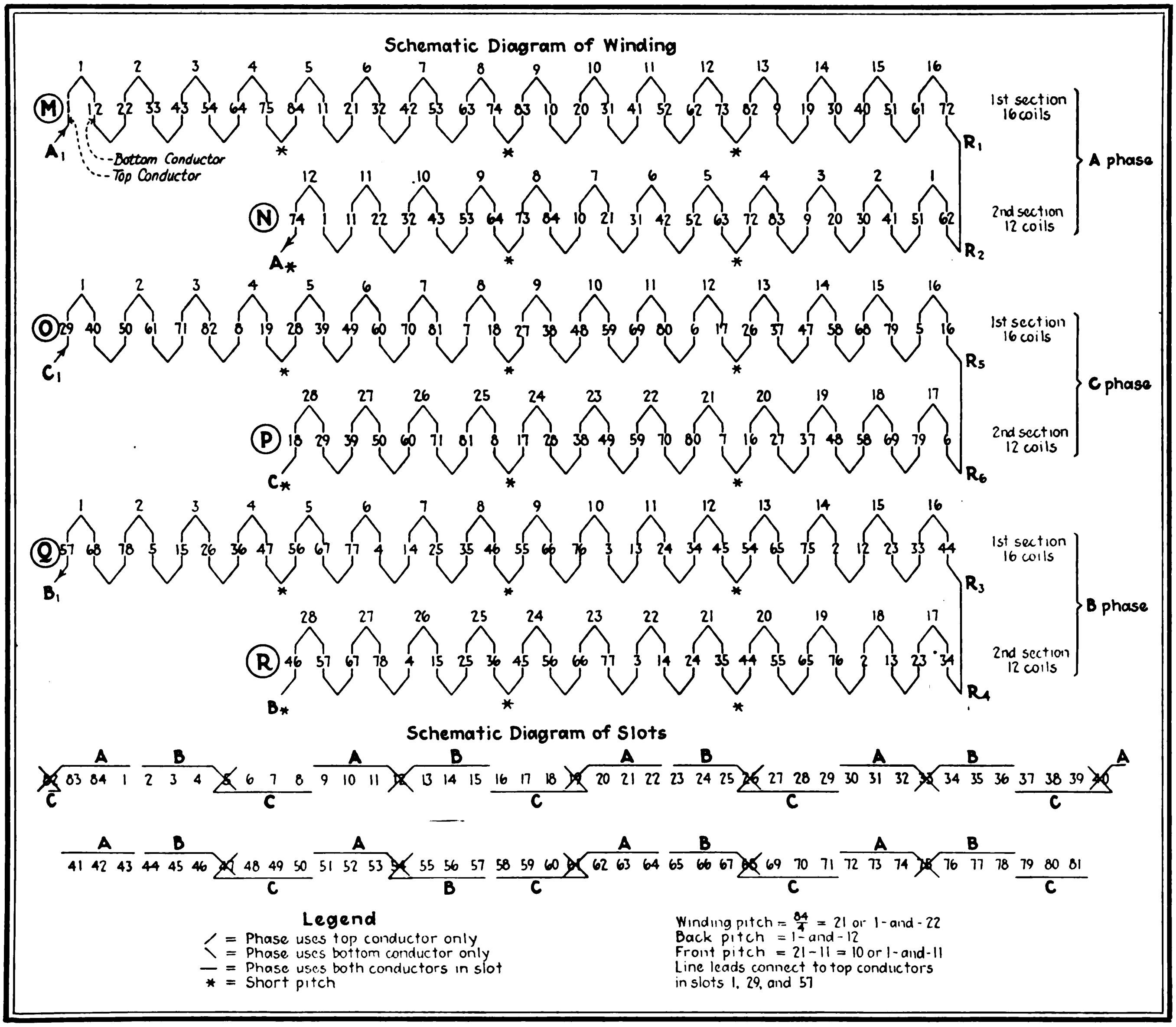

Fig. 2—This diagram shows the method of laying out wave windings where the number of slots is not a multiple of the number of poles.

The upper diagram shows the schematic layout of the sections. The lower diagram shows the overlapping of the phase belts (at intersection of diagonal lines), which must occur to the sections having unequal numbers of coils.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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Chicago, December, 1924

A Lesson from the Southern Textile Exposition

FEW opportunities are offered men in charge of industrial operations to study new developments in equipment and processes comparable with the textile exposition held this year at Greenville, S. C., except at the machinery exposition associated with the annual meeting of the Association of Iron and Steel Electrical Engineers and the National Safety Congress. This year at Greenville, S. C., Oct. 20 to 25, the Sixth Southern Textile Exposition surpassed in extent and nature anything of the kind heretofore held. Operators visiting the exhibition hall could see in actual operation practically every type of textile machinery made by seventy-five exhibitors, with the latest practice for its operation through the use of the most efficient power drive, transmission and control equipment made by 114 other manufacturers. These 189 exhibits were supervised by experts who were prepared to give practical answers to any installation or operating problem that might come up.

From the standpoint of operators this exposition was of marked educational value, for they could observe the performance of the newer types of equipment they are not thoroughly familiar with and get first-hand information on operating details from representatives of the manufacturers whom they would seldom see and thus establish acquaintances that will take away the formal nature of future correspondence on their operating problems.

On the other hand, manufacturers of textile equipment and the auxiliary drives and accessories used with it, could not hope to create in any other way an interest among anywhere near the same number of operating men in the brief period of six days under such favorable circumstances; namely, the getting together of thousands of mill engineers and operators, all discussing like problems from the viewpoint of improved operation and reduced costs through revisions in production processes that require new equipment.

Manufacturers of power drive, transmission and control equipment can profitably direct the benefits resulting from the Greenville Textile Exposition into other industrial fields, such as for instance, the wood-working field, paper making, and the manufacture of products made up of many small parts, where the problems in operation depend upon a maximum rate of production and high efficiency of equipment used with interruptions from breakdowns reduced to the last notch. Operators in these fields would welcome a comprehensive exhibit of the latest practices that are possible in new and revamped installations. Let us hope that the Southern Textile Exposition will be the stimulus for manufacturers to start something of this sort of interest to operators as an annual event in the other fields mentioned.

Standardize Your Resistors

THE problem of standardizing resistors has been with us a long time, but thus far little headway has been noticeable. Possibly an extreme case of the cost of not standardizing resistors was found in a new mill having about twenty-four automatic controllers. Each controller had from four to eight frames of resistance and for some unknown reason, no two of these frames were duplicates. To secure adequate protection against resistor failure it was necessary to purchase $1,000 worth of spare resistors.

Such an expenditure could have been prevented if the purchaser had insisted that the resistors be supplied in the fewest number of sizes and capacities. This would mean using oversize resistors in some cases, but this small additional cost would be overbalanced by the great saving in the amount of spare resistors that would be required.

Several plants have proved that their requirements can be satisfied with only five sizes of resistor frames. One operator intends to use five frames, each one to be painted with a distinctive color. If a red frame fails, the motor inspector's helper puts in a spare red frame without any fuss or trouble and the beauty of the scheme is that he can't make a mistake. Contrast this with hunting through a pile of a hundred or more resistors for one frame that is only slightly different from the rest.

The time to standardize resistance is when purchasing new equipment. A little forethought expended then will not only save on the original capital outlay but in the extent of production delays throughout the life of the equipment.

Housekeeping Costs in a Plant

A LESSON in plant housekeeping was cited by J. J. Stunzi, Consulting Engineer for the Lancaster (Pa.) Steel Products Corp. at the recent Safety Congress held at Louisville, Ky., which had the dollar sign so intimately attached as to make it impressive. He referred to an executive of a Middle West plant who was finicky in regard to clean floors and stairways and "raised Cain" with the superintendents about cleanliness with the result that more and more sweepers were employed until the condition of the plant pleased the boss.

Later it became the duty of Mr. Stunzi to write out the duties and functions of every employee in this

plant from the general manager down to the last sweeper, to determine the normal number of employees necessary for normal production. The results were interesting and surprising, for they showed where little and much work was being done. In the case of the sweepers, thirty-three had been employed but after studying their work and properly distributing it, it was found that seven sweepers could do the work of the thirty-three and did do it with a slight bonus in addition to normal pay. The saving to the company on this item alone was $27,000 in one year.

This is information enough to indicate the need of proper organization, analysis and supervision of the service about a plant that comes under the head of plant housecleaning and includes janitors, movers, sweepers, watchmen and the like.

Co-ordinating Plant Layout With Production

IN AN address delivered in Chicago, Ill., during the recent observance of Management Week by the local engineering societies, C. G. Stoll, Works Manager of the Hawthorne Works of the Western Electric Company, touched upon some practical points having to do with the co-ordination of plant layout with production. In opening his address Mr. Stoll said:

> Co-ordinating plant layout with production is primarily a problem of making an original plan that is sufficiently comprehensive to include the broad general solution of all the problems involved—that is, sufficiently flexible to adapt itself to changeable conditions without altering its essential character—and that looks far enough into the future to prevent any possibility of a costly, short-sighted use of the factory's capital and facilities.

Just what is included within the scope of these remarks and the responsibility of such a job as supervised by the author at the Hawthorne Works is best appreciated by reviewing the operations incidental to the production of the products turned out at that plant. They include: wood and metal working, glass making, textile dyeing, manufacture of lead pipe for cables, porcelain, vulcanized and phenolized fibre, rubber in sheet, rod, tube and molded shapes, the insulation of wire with textiles, making of enamels and insulating papers, and the conversion of copper billets into the finest of wires by rod-rolling and wire-drawing processes. These processes are side issues or incidental to the processes and operations that actually produce 110,000 different kinds of parts made from 18,000 different kinds, sizes and shapes of raw material in the assembling of over 13,000 separate and distinct forms of apparatus.

These figures, associated with the fact that over eighty acres of floor space is devoted to the production of these products, furnish sufficient information to impress the fact that without co-ordination of plant layout with production, nothing short of hopeless confusion could be expected. The whole problem is reduced to simple elements, however, through the co-operative functioning of seven divisions of the manufacturing organization, which are: the technical, production, operating, inspection, industrial relations, clerical and development branches.

The first or technical branch, which might be called in other work the specification or engineering division, determines how operations should be conducted and *with what* materials and equipment; the production branch determines *when* and *how much* output is required, while the operating branch is the *do it* department, which comprises all the actual producing departments and follows the instructions of the first two branches. The inspection branch operates all the inspection facilities of the works; the industrial relations branch has to do with the human side of the business; the clerical branch determines and specifies the detail routines by which work shall be conducted in order that a definite accounting procedure may be followed, figures the payroll, the costs of the products, pays for purchases, and so on, while the development branch is set aside for research and development of manufacturing processes and equipment.

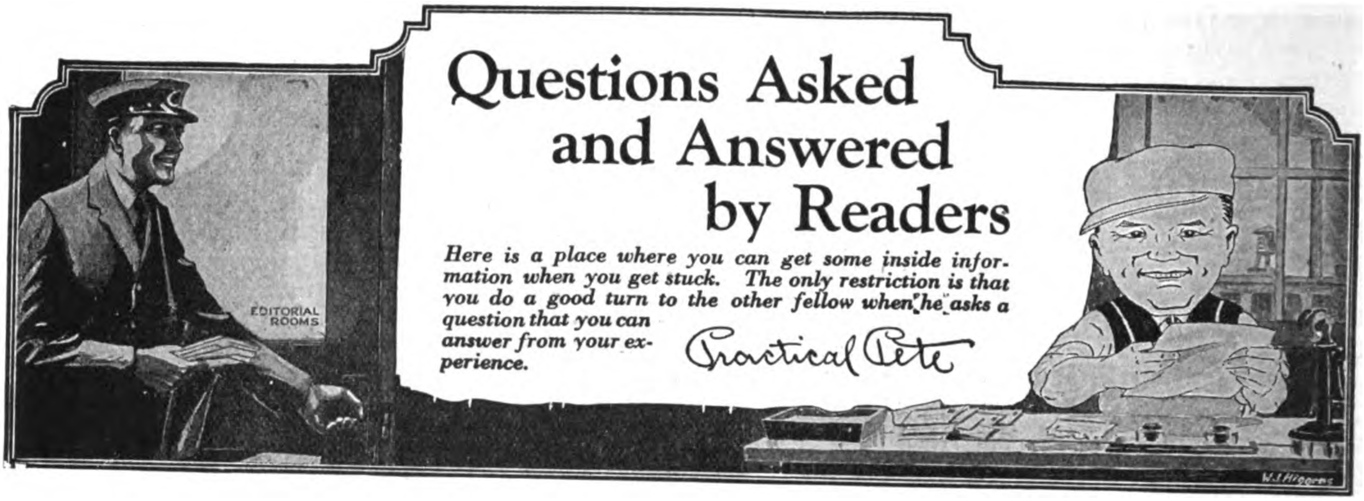
Thus it is seen that what appears from its scope to be an intricate production problem is reduced to simple elements that mainly depend on the concentration of responsibility for various functional phases of manufacturing activity into definite branches, each under the direction of a superintendent working with and not independently of other unit branches. This plan will bear careful study and application in many other lines of industrial work that call for departmental activities and the assignment of responsibility therefor.

Use Better Limit Switches

SHOULD we use crane-hoist limit switches and what should we expect of them? Arguments were advanced on the floor of a recent convention of plant engineers that it is better to do without limit switches and trust to the skill of high-grade operators. This is quite possibly true where use is made of makeshift limit switches that are liabilities rather than safety devices. But even so, high-grade operators are not infallible. Moreover, the control might jam, thus preventing the operator from shutting off power in time to prevent expensive damage and resulting shutdowns.

A recent accident in a large steel plant bears out this point. This plant is equipped with cranes of various ages, each crane having a limit switch representing the best thought of its day. Nothing had been done towards putting in modern limit switches. Dependence was placed on the limit switch in use and the skill of the operator. Eventually the time came when the operator made a mistake, the limit switch did not correct it and the load fell on a control pulpit below. The results were serious. The man in the pulpit was permanently disabled, the control in the pulpit was demolished, and the mill was tied up for four hours during a rush period. The crane was out of service for nearly a day. Needless to say, this plant is replacing their obsolete homemade limit switches with modern types and henceforth is not going to rely on the operator to stop the hoist motion of a crane at the upper limit of travel.

The solution of the limit switch problem is to obtain the very best switch that can be bought. A boiler is protected by a safety valve that is *not* a homemade contrivance. The design of the safety valve is very carefully worked out, tested and proven. Moreover, it is frequently inspected and given service tests. Can we afford to be satisfied with anything less in the case of a limit switch? Even though equipment be properly installed it does not necessarily follow that it will always stay that way.



Who Can Answer These?

Determining Size of Conductors for Intermittent-Rated Motors—Will some reader of INDUSTRIAL ENGINEER please give a method of computing the sizes of rubber-covered cables to be used for connecting intermittent-rated motors—particularly half-hour rated crane motors?
Montreal, Can. F. P.

• • • •

Voltage Rating of Fuses for 440-Volt Circuits—Will some reader please advise me as to the proper kind of fuses and fuse cutouts to use on 440-volt, three-phase, 60-cycle circuits? Should I use 600-volt or 250-volt fuses and cutouts? (2) Is it practicable to use fuses above 300-amp. rating as entrance fuses, or would it be better to use a circuit breaker?

Any information that you can give me will be greatly appreciated.
Marion, Ohio. G. R. K.

• • • •

Using Steam Engine as Air Compressor—I should like to know if it is possible, or practicable, to convert a steam engine into an air compressor. If so, what changes will have to be made and what will be the approximate cost? This is a 20-hp. engine mounted on a 25-hp boiler. The engine is of no use to me now, but I could use it to good advantage as an air compressor, driving it with a motor, with the boiler serving as the air tank. I shall appreciate any suggestions you can give me.
Accord, N. Y. H. D. V.

• • • •

Should Coils Be Purchased or Made in the Repair Shop?—We have in our plant about 1,000 motors ranging from 3 hp. to 100 hp. Roughly, one-third of these are older-type motors, while the remainder are of modern type. We have our repair shop, but so far have not attempted to wind our own coils. There is a feeling that we should do this, but before making any decision I should like to get the opinions of readers of INDUSTRIAL ENGINEER on the feasibility of doing this work. Will it pay us to do it? Can anyone give me some idea of the nature and approximate cost of the equipment needed?

I shall be very grateful for any information or suggestions you can give me.
Chicago, Ill. L. A. M.

• • • •

Method of Lining Up Conduit on Ceiling Beams—I wish some reader would please tell me the quickest and proper way to line up ½-in. conduit on the ceilings of mill-type buildings when you are breaking around the beams, using condulet fittings only at the bottom of the beams and also between beams, for lights. Some say it is best to put all of the pipe clips up first by using a chalk line and plumbing down; then you can take the line down and it will be out of the way. Others say to snap the line and take it down, but this method does not make a mark between the beams. As the thickness of the fittings must be taken into consideration, should one go by the edge of the fittings, by the edge of the pipe or by the center of the pipe? Also, should the clips be put up first, or is anything gained by so doing?
Worcester, Mass. R. S. T.

• • • •

Method of Driving One Generator with Two Engines—Can some reader suggest a practical and efficient method of driving a 50-kw. alternator by two oil engines of 37½ hp. and 50 hp., respectively, so that either or both engines may be used singly or together? If it is possible to devise such a drive with these engines operating singly or together I would have a selection of three horsepower capacities, 37½, 50 87½, with which to meet the power demands. The peak load is about 45 kw., but the load is often much less than this. With such an arrangement it would not be necessary for me to buy a second alternator and install synchronizing equipment.

I shall be very grateful for any advice or suggestions you can give me.
Youngstown, Alta., Can. W. C. A.

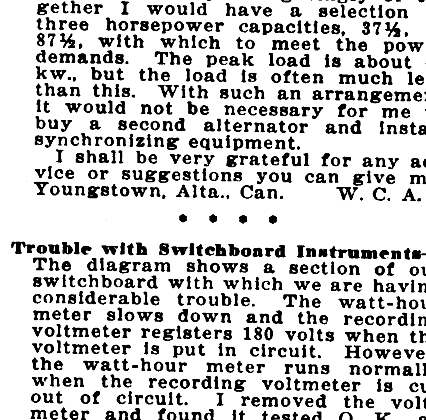
• • • •

Trouble with Switchboard Instruments—The diagram shows a section of our switchboard with which we are having considerable trouble. The watt-hour meter slows down and the recording voltmeter registers 180 volts when the voltmeter is put in circuit. However, the watt-hour meter runs normally when the recording voltmeter is cut out of circuit. I removed the voltmeter and found it tested O. K., as does the watt-hour meter.

No. 2 light on the ground indicator burns at full brilliancy on account of a ground on the meter circuit, which can not be traced out because the plant operates 24 hrs. a day. No. 1 light does not burn.

When a test light is put across the voltmeter terminals, with the voltmeter cut out of circuit, it burns dimly, as does No. 1 light on the ground indicator.

Can someone tell me what and where the trouble is?
Iola, Kan. G. E. G.



Answers Received To Questions Asked

Removing Concrete Foundations by Blasting—We want to remove the foundation of a large engine and I should like to have the experience of other readers in removing foundations by explosives or in other ways. How can I keep down the concrete dust while drilling the foundation? If we blast the foundation how can I keep pieces from flying and damaging nearby machines? Will it be necessary to take the windows out? What explosive works best and how much should be used for a shot? I shall appreciate any suggestions you can give me.
Detroit, Mich. A. H.

In reply to the inquiry by A. H. in the October issue, a short time ago we removed a large concrete engine foundation by blasting and the method used was as follows:

Starting at the edge of the foundation and about 1 ft. in from the edge we drilled a series of holes approximately 2 in. in diameter and 18 in. deep, spaced about 3 ft. apart. We used a pneumatic rock drill for putting down the holes and 2 min. was about the average time required per hole. Ordinary black powder was used. The size of the charge used was from one to two ounces. This can be determined to suit conditions by starting with a very small charge and increasing until the desired effect is produced. The holes were blown out with air after drilling, and the charge placed in the bottom of the hole. A wad of paper was rammed on top of it and then the balance of the hole filled with earth, well rammed. We have tried both the time fuse and the electric fuse and find the latter much to be preferred.

We always have plenty of old fibre cartridge fuse cases around and we utilized these for the charges. A fuse was made up by twisting two No. 16 fixture wires together, the pieces being about 10 ft. long. The wires at one end were joined by a piece of 2-amp fuse wire about 1 in. long; the other ends of the wire were joined to a flexible cord with a plug at the end to fit a standard lamp socket. The end with the fuse wire attached was inserted in one end of the old fuse shell by removing the cap at one end. The powder charge was then poured in and after making sure that the fuse wire was covered by the powder, the end of the shell was plugged with paper.

After the charge was in place and the hole plugged a mattress was placed over the hole. This mattress consisted

of a light wood frame covered with several thicknesses of burlap. In size it was about 8 ft. square. We held the frame down by placing a few sand bags along the edges. The charge was exploded by screwing the plug into a convenient lamp socket and turning on the current. The plug should be removed after each "shot" for safety to prevent the possibility of a premature discharge through someone accidentally turning it on.

The burlap mattress will keep the pieces from flying and if wetted will stop most of the dust. If the shots are gaged right there will be no necessity of removing the windows.

We blasted for a week in one of our departments which was in full production, and had no trouble whatsoever, with holding up of production, broken glass, damaged machinery or personal injury. L. J. CLAYTON.

Ass't. Mechanical Engineer,
The Goodyear Tire & Rubber Co. of Canada, Ltd.,
Bowmanville, Ont., Can.

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Selection and Application of Carbon Brushes—Can any of the readers of INDUSTRIAL ENGINEER give me any information on how to choose and properly apply the various grades of carbon brushes? I should like to know how a practical man can by inspection and simple tests choose a suitable brush for a job or determine what application a certain brush is most suitable for. I have seen references to the electrolytic action between brass collector rings and carbon brushes and should like to know the cause of this action and if there are any means of overcoming it.
W. A. P.
Smooth Rock Falls, Ont., Can.

Referring to W. A. P.'s question in a recent issue, it is impossible by inpection and tests to determine with 100 per cent accuracy a suitable brush for a job. This is proven by the fact that large manufacturers of electrical apparatus make extensive tests in selecting proper brushes for use in their machines.

It is important that the brush be of sufficient carrying capacity and the contact drop sufficiently high to reduce short-circuit currents in the coils to a minimum. In general, for stationary, flush-mica machines with speeds up to 3,000 ft. per min. a carbon-graphite brush containing sufficient abrasive to keep the mica flush with the bars is satisfactory. For stationary undercut machines an absolutely non-abrasive electro-graphitic brush should be used. On high-speed slip rings, where absolutely no cutting or wearing of rings are essential factors, a medium-resistance graphite brush is suitable. For rings of rotary converters and slip-ring induction motors where the current density exceeds 75 amp. per sq. in. a metal-composition grade of high carrying capacity must be selected.

The average user of carbon brushes gives little thought to spring tension. This is of supreme importance for an ideal brush may be ruined by insufficient pressure against the revolving part. As a rule an increase in spring tension increases the brush friction, but at the same time gives a lower contact drop. Consequently in giving a figure for brush pressure both of these losses must be considered and the value given be a compromise between the two. In general use the lowest brush pressure that will give good contact. This is seldom below 1¾ lb. per sq. in. Few brush manufacturers agree exactly as to the proper spring tension necessary for certain classes of work. This is because various constituents of a brush determine to a large degree the correct pressure regardless of the duty to be performed. For this reason it is advisable to consult the brush manufacturer.

Stackpole Carbon Co.,
St. Marys, Pa. C. O. BENSON.

* * * *

Method of Checking Alignment of Lineshafting—We have two long, and several shorter lengths of lineshafting which I know is somewhat out of line, probably due to settling of the building. I shall appreciate it very much if someone will give me a simple method of lining up these shafts accurately in the hangers, so as to reduce friction in the hanger bearings.
Milwaukee, Wis. S. V. B.

In reply to S. V. B. in the October issue, when aligning shafting without any special equipment I would suggest that he first run a line parallel to the shaft at the same distance from the floor as the center of the shaft, and as near the shaft as it can be conveniently put, and yet clear all hangers and pulleys. Have this line exactly the same distance from the center of the shaft at each end.

Then, using an ordinary carpenter's level and a straight-edge equal in length to the distance between the hangers, start at one end of the shaft and by means of the straight-edge and level find out how much, if any, the second hanger is higher or lower than the first. Also measure over to the line and determine if this hanger is out to the right or left, and if so how much.

Now using a chart prepared as shown in the illustration, proceed the entire length of the line, and obtain the position of the shaft at each hanger.

You can then examine each hanger and decide if it is practicable to put it where the chart calls for. In some cases it may be easier to raise or lower the entire shaft, or to move it sideways slightly. If you find the shafting so much out of level that it would be too expensive to make it level, it may be "graded in."

To do this divide the amount which one end must be lower than the other, by the number of spaces between the hangers, which will give the amount that each hanger must be higher or lower (depending on whether you start at the low end or the high one) than the one before it.

After the shaft has been put in the proper position, according to the chart, go over it once more as a check upon the accuracy of the work.

When the shafting in a plant is periodically aligned, file the charts away for future reference; then by comparing a number of charts obtained from any one length of shaft it can be determined if any of the hangers have been out of line in the same direction each time, and if so, the trouble can be located and remedied.

Head Machinist, DONALD MAXFIELD.
Old Town Woolen Co.,
Guilford, Me.

LOCATION- ____________
DATE - ____________

Hanger No.	High	Level	Low	Right	Line	Left
1		x			x	
2	3/16"				x	
3	1/8"					1/4"
4			1/8"			1/8"
5			3/16"		x	
6			1/4"	1/8"		
7			1/8"	3/16"		
8		x			x	
9		x				1/8"
10		x			x	

This chart is used to record the data taken when checking the alignment of shafting.

* * * *

Can Direct Current Be Obtained from Ford Spark Coil?—Will some reader please tell me (1) if I can connect a Ford spark coil to a 110-volt line through a 6-volt, step-down transformer and use it for the ignition system of an engine? (2) Under these circumstances would the high-tension side of the coil deliver a.c. or d.c.? (3) What is the voltage on the high-tension side of one of these coils? (4) Can I put 110 volts a.c. on the high-tension side and charge a storage battery from the low-tension side? (5) Can you tell me how to make a good rectifier for charging storage batteries?
Bellingham, Wash. E. M. D.

In answer to the question by E. M. D. in a recent issue of INDUSTRIAL ENGINEER, I would say (1) you can use a Ford coil for ignition and get good results.

(2) Alternating current, but not of true sine-wave form.

(3) From 10,000 to 15,000 volts, through interrupter adjustment. Higher voltages can be obtained by increasing the voltage of the primary supply, but this will soon burn out the contact points.

(4) No, because the current is a.c. Even if rectified this current from the low-tension side of the Ford coil (provided the coil is connected as you describe) would be too weak for charging storage batteries. The current for charging storage batteries must be d.c., either continuous or pulsating.

(5) Directions for making a rectifier for charging storage batteries can be found in some of the books containing instructions for making wireless telephones.

Concord, Mass. DONALD FERGUSON.

* * * *

How Does the Lundell Motor Operate?—Can some reader of INDUSTRIAL ENGINEER give me a simple explanation of the theory of operation of the Lundell d.c. motor made by the Sprague Electric Co.? This motor has only one field coil (either series or shunt) which is placed in the frame in such a position that the armature rotates in the center of the coil. In other words, the field coil is wound around the armature.

I should like to know how and where the magnetic field poles are formed.
Philadelphia, Pa. C. F. S.

Replying to the question by C. F. S. in the October issue, if he will examine the motor in question he will notice that it is a two-pole machine. The field frame splits in two at an angle of 90 deg. to the armature shaft, with one pole piece cast on each half in such way as to hold the field winding in the frame at about a 70 deg. angle to the armature, allowing one pole piece to come in on either side of the field coil and making a north and a south pole.

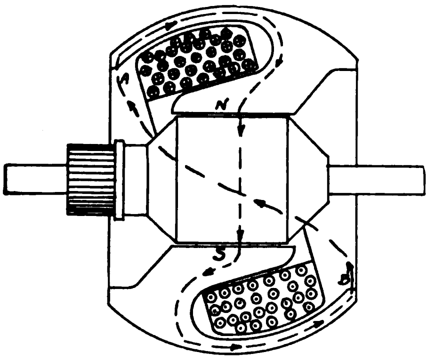
This style of field winding eliminates any chance of wrong field connections

except when the machine is compound wound, in which case it would be as easy to get the windings opposed as in any other type of motor.

Middleport, Ohio. ELZA HERRMANN.

* * * *

The question asked by C. F. S. in the October issue is answered by reference to the accompanying diagram. The peculiar form of a single-coil, bi-polar field system used in this motor gives two salient poles from a single coil. Each of these poles is diametrically opposite to the other. The magnetic circuit is outlined in the diagram by the dotted line.



Magnetic circuit of Sprague round-type single coil, bi-polar motor.

With the current in the field coil as indicated (flowing into the paper at the crosses, upper section, and coming out at the dots, lower section), the lines of magnetic force follow the path from one pole to the other through the armature core, and return from (B) to (A) through the frame. There occurs also a leakage of these lines from the tips of the poles to the points (A) and (B), but since this gap is quite large the amount of leakage is comparatively small.

Honesdale, Pa. J. M. WALSH.

* * * *

Method of Running Open Wiring in Mill-Type Buildings—I wish some of the readers of INDUSTRIAL ENGINEER would give me their opinion on the best way of running open wiring in buildings of mill-type construction. Assuming that No. 8 or larger conductors are used, should these be run on the roof trusses, on the ceiling beams or on the side walls? Should the conductors be supported by cleats or on knobs? What kind of cleats and knobs should be used? I should also like to know when and how strain insulators should and should not be used. Is there any preference as to the type of strain insulator? Any information you can give me will be much appreciated.

Worcester, Mass. R. S. T.

Referring to R. S. T.'s question in the September issue, the following materials have been used with success for open wiring in the roof trusses of mill-type buildings. For small wires the most useful combination has been standard No. 4½ porcelain insulators on Universal No. 501 insulator supports. For medium-sized wires the Peirce wireholders are very useful. For cables an excellent job can be done with Peirce secondary racks at intermediate supports and Giant strain insulators at end supports. The most satisfactory place for fixing the supports is on the bottom chord which is the lowest horizontal member of the roof truss, but if piping or the building structure prevents, another member may be used. No hole should be drilled in the structural steel. The racks can be fixed in place by bolts passing through between the longest members of the racks and between the angles of the roof truss member. The strain insulators should be attached to a rectangular bar forged in the shape of a hook conforming to the section of the structural member of the building which is to take the strain. D. W. BLAKESLEE.

Electrical Engineer,
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

* * * *

In answer to R. S. T.'s question in the September issue, the roof trusses usually make the best support for large wires and cables; here they are less likely to be injured and a clear space can usually be found that is accessible. When conductors are supported on the ceiling beams, they are generally in the way of shaft hangers and the rigging used when handling machinery on the mill floor.

Wires should be supported by single-wire cleats secured by wooden screws or lag bolts. It is advisable to line out one row of cleats with a chalk line. With the larger cleats it will be found much easier to start the screw if small holes are bored in the beams with a gimlet bit. A sheet-iron templet can be easily made for marking these holes and will be well worth the time spent in making it by the improved appearance of the rows of cleats.

All heavy wires and cables should be secured to strain insulators at dead ends. A convenient method of doing this is by the use of G. E. strain clamps or Matthews feeder clamps to hold the cables. The strain insulators should be anchored by long-thread eye-bolts so that the tension on the wires can be equalized. A strain insulator of the Giant strain type has been found very satisfactory by the writer.

Where steel frame construction is used the cleats should be secured to wooden pieces bolted to the roof trusses. These pieces should be at least 1½ in. thick.

Charleston, W. Va. EDWIN C. BIRGE.

* * * *

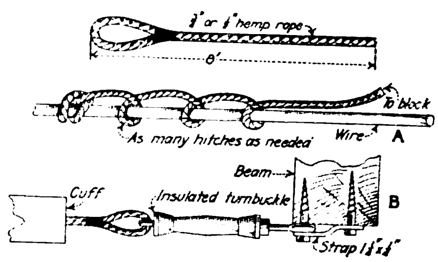
In answer to R. S. T.'s question in the September issue, open wiring is permissible in mill buildings, but the work must be very neat. No. 8 wire or larger does not require supports every 4½ ft. as smaller conductors do. Accordingly it may be supported at every beam. Rubber covered wire may be used, or cambric insulated if the voltage is high enough to warrant it. I would suggest asbestos covered (white wire) if low voltage is used. If the building in question is a cotton mill, asbestos-covered wire will make an installation that harmonizes with the surroundings. All wires must be installed on the under side of beams or trusses. I would suggest using split porcelain cleats provided with two holes for screws. Round head, blued wood screws or galvanized lags make a neat installation, and they do not burst cleats as flat head screws do. The proper size of cleats for a certain size of wire and insulation may be obtained from any electrical dealer's catalog.

For short spans, not over 100 ft., use plain strain insulators at one end and insulated turnbuckles at the other. The wire should be served directly into the strain insulators and turnbuckles, if it is not too large; if it is too large a link can be used. In spans of 125 ft. or more I would use insulated turnbuckles on both ends of the line.

After deciding on the length of line serve strain insulator to wire and then reel off the proper length, allowing for serve to insulated turnbuckle.

Procure a light, stout staging and "pull a line" under beams or trusses about 50 ft. long. Take a square, combination preferred, and mark the center of each cleat, usually about 6 in. apart. The holes may be laid off and a drill of the right size used to drill the holes before attempting to fasten up the wire. If neatness is not essential the wire may be pulled up fairly tight with turnbuckles and the cleats put on.

When the holes are all drilled the strain insulators are fastened and a cleat put loosely on every other beam to hold up the slack in the wire. The eyes of the turnbuckles are then fastened at the other end of the line. A rope hitch is made around the wire and a chain or rope block is used to haul up the slack. The wire is pulled taut and the turnbuckle is let out until only one or two threads hold. The wire is measured for the serve and the block slacked off. It usually saves time to serve on the floor or where the electrician or helper is fairly comfortable. When the nut end of the buckle is served on it is pulled into place by blocks and two or three threads are caught. The blocks are removed and all cleats are put on loosely; when this is done the buckles are tightened to suit, the tighter the better unless exposed to cold or snow and ice.



How rope hitch is made, A, and method of fastening strain insulators and turnbuckles, B.

Fiber cuffs can be used to insulate serves unless a high voltage is used. A 3-in. cuff about 18 in. long is sufficient. Cuffs must be placed on the wire before fastening up and they are very easy to forget. I would suggest using some form of solderless cable tap, (I prefer Dosserts) for making taps. They are much neater than a splice or ordinary screw tap. A brace or power screwdriver or socket wrench for the lags will speed up tightening of the cleats.

The reason for using a rope to pull up slack wire is that it does not cut or

mar the insulation and a cable basket cannot be used very well in this case. Plain wood strain insulators are generally used but many suitable types are listed in dealers' catalogs. The illustration shows the method of fastening strain insulators and turnbuckles and also the rope hitch.

Any mechanic who puts a line up in the above manner will have a line that is straight and neat if he is reasonably careful in lining up the cleats.

Birmingham, Ala. GRADY H. EMERSON.

* * * *

Replying to R. S. T.'s question in the September issue, I always prefer to run open wiring, as well as conduit, on the ceiling or roof trusses. In the first place I am able to space the conductors better than when I run them on the side walls. Also, they can be strung tighter, which makes a neater job. Conductors, when run on the ceiling, can as a rule be supported at shorter intervals. Of course, that all depends on the general layout of the job.

I prefer single-conductor, split-type cleats. As regards using strain insulators, I use these on heavy conductors where I have to change from a vertical to a horizontal run inside of buildings where I can support the conductors at longer intervals in order to take the strain off the cleats.

For smaller conductors I use two or three cleats as strain insulators. At the ends of the runs I generally use the Peirce insulated fork and turnbuckle as a strain insulator. By using a turnbuckle it is possible to draw the conductors tighter than can be done by using a block and tackle only.

I hope that these suggestions will help R. S. T. in his problem.

Chicago, Ill. A. NOEPPEL.

* * * *

Jackshaft Bearing of Mill-Type Motor Leaks Oil.—I am having trouble with oil leakage from the jackshaft bearings of mill-type motors. These bearings are large, running from 3½ to 7½ in. in diameter. They are split and held in brackets which are integral with the motor frame. Both ends of the babbitt bearing extend beyond the bearing housing. There is one oil ring in each bearing. The oil leaks out around the shaft at the ends of the bearings and then drips on the surrounding apparatus. At times the oil will be drawn out of the bearing to such an extent that the oil level will fall too low for the ring to dip in the oil.

I shall appreciate it if some of the readers of INDUSTRIAL ENGINEER will give me the remedies they have used to overcome this trouble.

South Chicago, Ill. O. C.

In reply to O. C.'s question in the September issue, I think he will find much improvement if he will cut a groove in each end of the bearing about ½ in. from the outer end and then cut lateral or diagonal grooves back to the center of the bearing and there provide a hole for the oil to drain back to the housing again. The groove around the bearing near the ends should be about $\frac{3}{16}$ in. wide and $\frac{3}{16}$ in. deep and be made with a round-nosed tool in a lathe. The other grooves will no doubt, have to be cut by hand with a sharp, round-nosed chisel or tool made purposely for the job. It will not be necessary to cut diagonal grooves in the top half of the bearing, as the oil on top will be drained to the bottom by the grooves cut around at each end.

Donnacona, P. Q., Can. LEE F. DANN.

* * * *

Referring to the question in the September issue, Keystone grease, No. 6 light density, has in many plants replaced oil for the lubrication of ring oil bearings, due to its ability to maintain its original consistency through a wide range of temperature. Where an oil which has the proper viscosity for this class of lubrication, thins down and begins to creep along the shaft and out of the bearing at temperatures of say 110 deg. F., to 130 deg. F., the liquid grease is not affected by the heat, and therefore, stays in the bearing.

Granting that mechanical conditions are right, it seems to us that a trial of this lubricant would largely overcome the trouble.

No. 6 Light is wholly liquid and is made expressly for ring oil bearings, but as before stated it is unlike oil in that it will resist a wider temperature range without an alteration of its original density. F. D. STREET.

Sales Engineering Dept.,
Keystone Lubricating Company,
Philadelphia, Pa.

* * * *

Is it Good Practice to Weld the Bars in Squirrel-Cage Rotors?—We have a Westinghouse type CCL 2-hp., 1,200-r.p.m., 220-volt, three-phase motor, whose rotor bars were fastened to the end rings with one screw and soldered, and were insulated in the slots with fishpaper. This motor drives an air compressor and is controlled automatically. Recently it failed to start when the switch was closed and when it was discovered the winding was roasted, the solder had run out of the rotor and the slot insulation was destroyed.

The motor was rewound and the rotor welded. The bars were not insulated again. The screws holding the bars were left in and the spaces between the ends of the bars were filled clear up with Tobin bronze. Now the motor refuses to start the load, but carries it nicely after it is once started. The winding is the same as before and there are no hot spots in either stator or rotor. I took a light cut off the end rings, but this made the motor weaker.

I believe the rotor bars need slot insulation, but it will be a big job to cut off the weld and make new bars. Does welding these rotors usually cause this trouble? Previous to this I had always reinsulated and soldered the bars and had no trouble. If welding is good practice I want to do it, but if it is not I want to leave it alone. Any information you can give me will be much appreciated.

Also, can you tell me where I can get felt wicking, such as is used in the oil cups of small motors?

Regina, Sask., Can. G. D.

Replying to G. D. in the September issue, it has been our practice for several years to weld all rotors which come in with the solder thrown out. As a matter of fact, welded rotors have superseded soldered rotors entirely. I believe G. D.'s trouble lies in the fact that he filled in the space between bars with the new metal. This had the effect of increasing the section of the end rings, thereby reducing the resistance in the squirrel-cage winding. This in turn reduced the starting torque of the motor.

When welding CCL rotors it is our practice to weld only along the bottom edge of the bar and not fill in the space between bars. Since it will probably be difficult to remove the Tobin bronze from between the bars I would advise G. D. to take another good cut off the end rings and thus reduce the cross section.

With reference to the slot insulation on the rotor bars, the current induced in the squirrel-cage winding is of such low voltage that there is no tendency for it to travel into the iron and for this reason insulation is not used on present-day squirrel-cage windings.

I would advise him to apply to the motor manufacturer for the felt wicking used in the bearings.

Walkerville, Ont., Can. R. B. TURNER.

* * * *

In answer to the question by G. D. in the September issue of INDUSTRIAL ENGINEER, I have had very good success in welding rotors and find that it does not affect the operating efficiency, providing the bars are insulated from the laminations of the rotor. In one case where the insulation was removed the motor showed in operation the same characteristics as the one in question. After the bars were reinsulated the motor operated as it should.

Another thing that I have found out about welding rotors, is that it is very essential that they be perfectly balanced after the welding in order to remove any heavy spots. Otherwise, the rotor will cause serious vibration.

Goldfield, Nev. PHIL D. COMER.

* * * *

In reply to the question by G. D. in the September issue, I once had the same trouble with a 20-hp. CCL motor. I overcame it by reinsulating the rotor bars, soldering the end rings and tightening the screws and the motor has given excellent service for the past eight years. In the type of motor he speaks of the rotor bars should be insulated allowing the secondary current to follow the path of the copper. Under present conditions, the secondary current is flowing in all directions through the rotor so that it cannot exert the required amount of twisting effort to start the load.

Chief Electrician, EARLE N. DILLARD.
Booth-Kelly Lumber Co.,
Springfield, Ore.,

* * * *

G. D.'s trouble, described in the September issue, is due to the fact that the space between the rotor bars was filled in with metal flush with the top of the bars and, no doubt, extending back along the bar the width of the end ring. The result is that the end ring is shorted and a very low-resistance motor is obtained.

All of our service stations make it a practice to weld all rotors of this type, but they do not fill up the space between the bars with metal. Only a small fillet is put along the edge of the bar where it makes contact with the top surface of the end ring. After welding a light cut, $\frac{1}{16}$ in. to ⅛ in. deep, is taken off the end rings and bars in order to bring the starting torque back to normal. Welding is good practice, when it is properly done.

The only thing G. D. can do now is to chip out the metal between the bars or put a number of saw cuts in the added metal, between the bars. If this does not bring the torque back to where it

belongs, put a few saw cuts in the bars themselves. The cuts should probably be from ¼ to ⅜ in. deep.

The insulation on the bars need not be renewed as it is very seldom that the current will pass through the iron. The complete rotor can be dipped in Sterling varnish, or any good varnish that will bake hard. This will help somewhat, but is not absolutely necessary.

East Pittsburgh, Pa. A. C. ROE.

* * * *

Answering G. D.'s question in the September issue, the rotor bars should be properly insulated, as they came from the manufacturer, and every bar should have a very substantial connection with the end rings. If the screws are not enough, a thorough soldering or welding of each bar is needed.

Even in squirrel-cage motors, although the rotor carries no winding, if these bars get loose at the end rings there is trouble.

I recall one instance of a 25-hp. motor, in a large typewriter factory in Hartford, where a few bar connections loosened up, causing heat in the rotor and, as it was in the cellar, small sparks could be seen jumping from the rotor to the stator winding.

With nothing else at hand to work with except a large hand-size gasoline torch, and a small gas and air burner, the latter was used to heat a large patch of half-and-half solder all around both end rings at every bar, the rotor being partly drawn out of the frame for convenience.

After that no heating or sparking was noticed, although this motor was driving an exhaust fan 10 hr. a day, at full load.

Jamestown, N. Y. H. S. RICH.

* * * *

In answer to G. D. in the September issue, I do not think the trouble you are experiencing with your 2-hp., CCL Westinghouse motor is due to lack of insulation in the rotor. We weld rotors, both large and small, every day and never pay attention to the rotor insulation. The lack of starting torque is due to too much metal in the end rings. This will cause the motor to draw excessive current and refuse to come up to full speed.

I recently had an experience similar to yours with a 3-hp. 110-volt, G. E. motor which was rated at 16.5 amp., full load. When it came in it drew 65 amp. when running light.

The windings and connections were checked with the factory data and found to be O. K. On examination, we found that someone had welded a bronze ring on the rotor when the bars came loose. It was a neat job, but on checking over the weight of copper on the rings, we found the rotor had more weight than the stator, which does not agree with present principles of design. Generally speaking, the rotor carries about 80 per cent as much copper as is used in the stator. So we turned the excess off the rings and the motor operated satisfactorily.

On small rotors we always weld only the ends of the rings. On large rotors, we just spot the bars to the ring. We have never had any trouble and prefer welding to soldering. For welding we always try to use the same kind of material as is used in the rings or bars, so as not to change the secondary resistance materially.

I hope this information will be of some value to G. D.

NICHOLAS J. WEISS.

West New York, N. J.

* * * *

In reply to G. D.'s question in the September issue, it was all right to weld the rotor bars to the end rings as this makes a better and stronger job and no harm can be done by so doing, providing you do not add too much metal. However, I believe that in this case sufficient metal was added to the end rings to alter the resistance of the rotor materially. This would account for at least part of the trouble.

I believe that if G. D. reinsulates the bars he can overcome this trouble.

The felt wicking he mentions can be obtained from motor dealers or supply houses.

Muncie, Ind. GEORGE CROPPER.

* * * *

In answer to G. D.'s question in the September issue, I would like to say that his trouble is unusual, and seldom happens. I have seen numbers of rotors welded, practically all commercial sizes, and their operation has always been satisfactory. A slight additional heating might result but not enough to do any damage. I have removed the insulation from rotors and have seen numbers that came from the factory without any. Their operation has always been satisfactory. In the motor in question the removal of the insulation must have caused the trouble, because it would reduce the resistance and cause heating. In the case of a small motor I would think that a small amount of metal would be sufficient. In a rotor the higher the resistance, the higher the starting torque becomes, within certain limits. I would suggest that the insulation be replaced and the bars welded to a ring of the same composition and cross section as the original ring, not using any surplus metal. I am sure that this will remedy the trouble. I believe the rotor has too low resistance as it now stands. I have always observed that welding properly done is a success and many motors are coming from the factory welded.

Wicking for motors can be obtained from the manufacturer of the motor.

Birmingham, Ala. GRADY H. EMERSON.

* * * *

Use of Red Metallic on Repaired Armatures—After rewinding or repairing railway motor armatures a coating of Red Metallic and shellac is applied to certain parts—sometimes to the end of the commutator, or to the top of the bars where the leads are soldered on, to the projecting mica cone, and so on. Shellac mixed with it and applied seems to dry much quicker than straight shellac; also it makes a hard, permanent coating which has a certain cementing property, as when applied to the cone to prevent the fraying off of small mica pieces under operating conditions. However, Red Metallic is nothing but iron oxide, better known as iron rust, and is a good conductor of electricity. Therefore, I do not believe anyone, including myself, has any justification for using it, for it certainly is a conductor in the powdered state and probably is when mixed with shellac, although I have never had, or heard of, any trouble on account of its use. I use it as others do because the boss says to use it—and he does not seem to have any reason for so doing except that others before him have used it with no bad results.

Why could not the same quick-drying and cementing properties be obtained by mixing shellac with a non-conducting material such as plaster of paris or chalk? I should like to know what other readers think about the use of this systerious Red Metallic.

Oakland, Calif. S. H. S.

In the September issue, S. H. S. asked about the use of Red Metallic. We have a Sturtevant fan, the driving motor of which used to give us some trouble from shorts in the end of the commutator and burning to ground.

After replacing the micanite insulation, we gave the end of the commutator a heavy coat of Red Metallic and shellac and since then the commutator has not given any more trouble. The motor runs twenty-four hours a day and seven days a week, and since using the Red Metallic, we have had to repair the commutator only once in about three years.

San Francisco, Calif. C. H. PRATT.

* * * *

In answer to S. H. S., in the September issue I do not believe it is advisable to paint commutators as mentioned, although there may be on the market so-called oil and waterproofing preparations of which the writer does not know. Commutators and commutator parts should be purchased from the manufacturers of the motors; the copper and the mica will then be of the best. Any pits or cracks which may develop on the end surface of the commutator may be cleaned thoroughly so as to remove all oil and carbon deposits; then press into the places to be filled, asbestos crumbs and shellac, and dry with the blow torch. Pits on the working surface of the commutator and undercutting between bars, may be filled with plaster of paris mixed with water. These methods have been used with success in railway and mill-type motors in one of the largest steel and iron works.

Electrical Engineer, D. W. BLAKESLEE.
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

* * * *

Answering S. H. S. in the September issue, I would never try to use any conducting material as a non-conductor for any purpose, much less on 500- to 650-volt trolley lines.

There are many good, substantial armature varnishes on the market for just this purpose, and no risk is attached to their use. Shellac is not proof against water to any great extent, as it is likely to crack, blister, peel and soften when wetted repeatedly, and the addition of chalk, plaster of paris or iron oxide makes the composition all the more liable to absorb moisture, the very thing it is desired to prevent.

There may be some good reason for using this compound, but for better results I would suggest that a good make of armature varnish be procured for a trial; coat one or two armatures thoroughly and repeatedly and then dry them well. Note all the facts and the date and watch their operation over a period of time. The results will likely prove more satisfactory than when other materials are used.

Jamestown, N. Y. H. S. RICH.

Meaning of Motor Nameplate Data—Can some reader tell me what "Open Hp. 10, Amps. 75,—Closed Hp. 5½, Amps. 43," means in the case of a General Electric, d. c., compound-wound motor which has the following nameplate data: No. 95790, Form B, Speed 650, Volts 115, Open Hp. 10, Amps. 75—Closed Hp. 5½, Amps. 43. Pat'd Feb. 14-88 up to Jan. 31-99.
Mazatlan, Sinaloa, Mex. J. C. L.

Answering J. C. L.'s question in a recent issue of INDUSTRIAL ENGINEER, "Open horsepower" means the horsepower rating when all ventilating openings are used, and is the highest rating. In other words, this condition gives the maximum dissipation of heat.

The term "closed horsepower" means the horsepower rating when the motor is totally enclosed. Naturally the horsepower would be lowered, because there is less chance for the heat to escape. The heat would be greater under these conditions; so the horsepower rating is lowered in order to reduce the heating to a safe value. The totally-enclosed motor is used where the materials suspended in the surrounding atmosphere are injurious, or objectionable inside the motor.
Birmingham, Ala. G. H. EMERSON.

* * * *

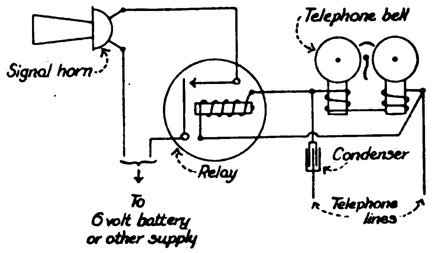
Connecting Extension Bell to Telephone—I shall appreciate it very much if readers will give me some information on the following problem. In our engine room we have a telephone which operates from the city system, through our own switchboard. When the engines are running it is impossible to hear the bell ring unless some one is standing close by the telephone. I wish, therefore, to install a large alarm or extension bell. How should this be connected? What voltage is used to ring the telephone bell? What voltage and type of bell should I use? Is it necessary to use a relay for this bell; if so, what type is preferable? Please give me a wiring diagram showing how this bell should be connected.
Chicago, Ill. W. A. B.

If W. A. B., whose question appears in the September issue, will secure a telephone relay manufactured by the Benjamin Electric Company, Chicago, Ill., and connect one side of it across the telephone line and the other side in series with a 110-volt bell across a 110-volt line, his troubles will cease. The ringing current on the telephone line energizes the relay and closes the contact on the 110-volt side, thereby ringing the bell. If he desires, he can have a 110-volt red light connected in multiple with the bell and located on the engineer's desk. The light will then call attention to the ringing of the telephone.
Chief Electrician, EARLE N. DILLARD.
Booth-Kelly Lumber Co.
Springfield, Ore.

* * * *

In reply to W. A. B., in the September issue, I would suggest that he install a signal horn instead of a large bell. In my experience, I have found horns to be far superior to bells from the standpoint of both operation and audibility. A horn can be obtained that will suit any voltage from 6 volts to 250 volts, a.c., or d.c.

For reliability of operation, it is probably best to use a six-volt storage battery on a 6-volt horn, but any reliable source of current will do, provided the voltage of the horn corresponds. A relay is nearly always required for operating the horn, the connection being as shown in the diagram. It will be seen that the coil of the relay is connected to the terminals of the telephone bell. This is essential, especially if there is a condenser in series with the bell, which is the case in most telephones. It is hard to say what voltage is used on your telephone bell, as this varies on different systems. In ordering extension bells or relays, the resistance of the bell ringers in ohms should be stated. This is usually stamped or printed on the bell coils. Of course,



Method of connecting signal horn to telephone line, for operation on a local battery through a relay.

if a bell is preferred, it can be connected in the same manner as the horn, using the same relay, and operating on a suitable voltage; or a bell can be obtained that will operate directly from the telephone bell terminals.

Any manufacturer of electric horns will supply the proper relay and directions for its installation if the system it is to be used on is described.
ERNEST DICKINSON.
Kimberley, B. C., Canada.

* * * *

In answer to W. A. B. in the September issue, if this telephone belongs to the Telephone Company nothing should be attached to it without their permission; however, they would install a bell for you, if needed. They will, of course, make an extra charge for the installation.

On the other hand, both a loud bell and a 110-volt ruby lamp could be installed to operate through a relay, the latter being made to work on the telephone line alternating ringing current, with the bell or light operated on either storage battery or city current as most convenient.

I would suggest that you write to the Western Electric Co., New York, N. Y., for such apparatus, as they make all kinds of telephone equipment.
Jamestown, N. Y. H. S. RICH.

* * * *

Answering W. A. B. in the September issue, when connecting extension bells to a telephone system, it is very necessary to ascertain the ohmic resistance of the bells in service. The usual resistance is 1,000, 1,200 or 2,500 ohms. In exchanges where the battery is common to all telephones and the operator is signaled by taking down the receiver, it is necessary to connect a condenser, usually 2 mf. capacity in series with the bell. In the case of a private line, the bells are connected in parallel with the line. If the line is a party line, ringing on the "ring" and "tip" side of the line, it will be necessary to connect one side of the bell to ground and one side to the ringing side of the line.

In case the system is of the magneto type, the condenser can be omitted and the bells connected as stated in the paragraph above.

Any manufacturer of telephone supplies can furnish a loud-ringing gong at a nominal price. The American Bell Telephone Company uses Western Electric bells almost entirely, but Kellogg and various other bells advertised in recent issues of INDUSTRIAL ENGINEER are satisfactory.
Goldfield, Nev. PHIL D. COMER.

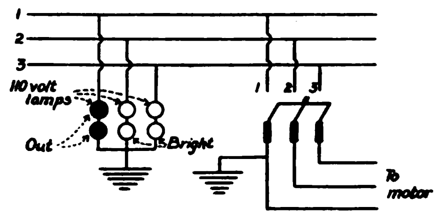
* * * *

Trouble with Traveling Cranes—I am having trouble with two traveling cranes which run on the same track and are used for loading and unloading stone in a mill. One crane is rated at 20 tons and the other at 30 tons. Each crane has two slip-ring motors of about 20-hp. rating, which operate at 220 volts, sixty cycles and are controlled by General Electric starters. When both cranes are in operation the hookers on the ground get a shock every time they touch the chains which are used to carry the load. When either one of the cranes is idle, the men do not get a shock. I have tested out all circuits with a magneto and was not able to find any indications of trouble. I shall appreciate it very much if any of the readers of INDUSTRIAL ENGINEER can tell me how to find this trouble.
Bloomington, Ind. H. M.

In reply to H. M.'s inquiry in a recent issue, it is very evident that he has two grounds, one on each crane. He fails to state, however, whether this is a two-, three- or four-wire system. I will assume, therefore, that it is a three-wire system, as this is the most commonly used in industrial crane operation.

Ground lamps should be installed in a convenient place so as to be visible from the crane cab. This is desirable from the standpoint of safety for the men as well as for the convenience of the electrician. These lamps should be installed as shown in the accompanying sketch.

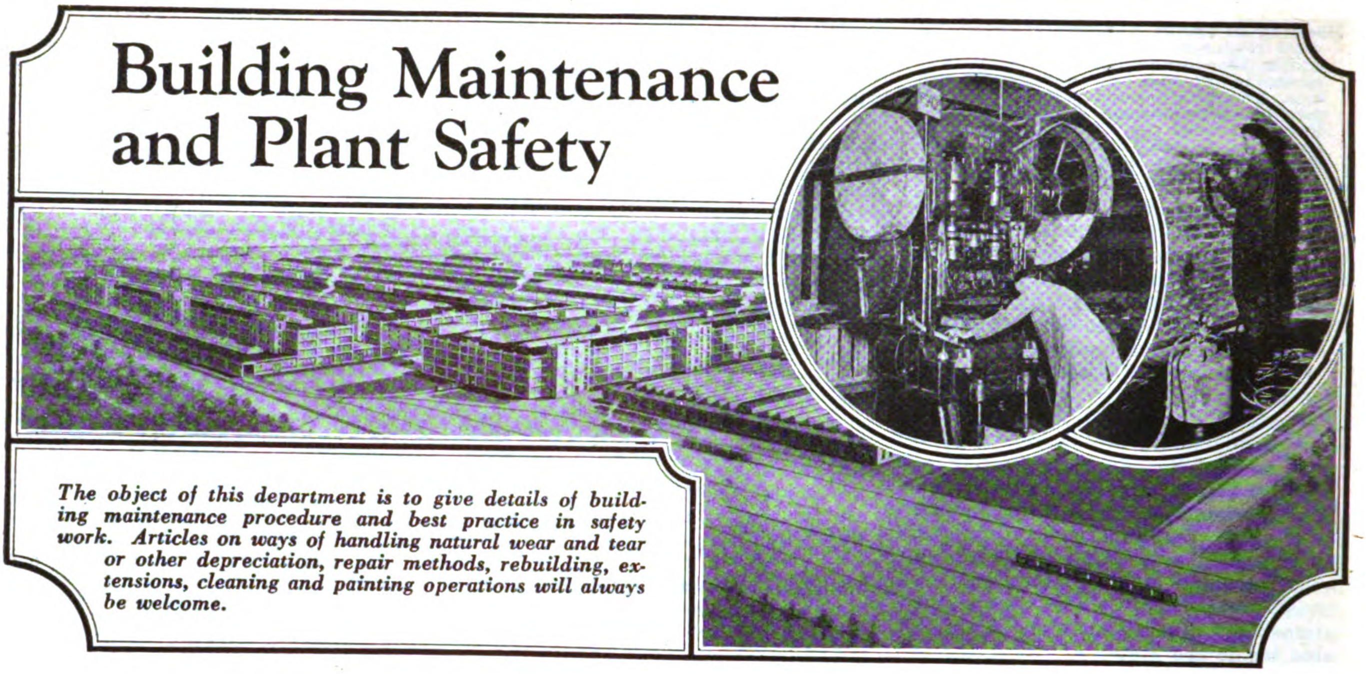
After installing the ground lamps one crane should be run with the chains on a good ground and the lights noted. If the lights go out on one phase and the lights on the other two phases brighten, the ground is on the dead phase, which can then be traced to the motor.



Method of installing ground lamps to detect grounds on crane.

After one crane is cleared up in this manner, the other crane should be treated similarly. In case the trouble cannot be found, but grounds exist, connect both of the grounded phases on the motor side of the controller to the same phase on the trolley. This can be done by changing all three wires and still not change the direction of rotation of the motor. Although this procedure is not to be recommended and should not be necessary, inasmuch as it should be possible to locate and clear up any grounds which exist, it will keep the men from getting shocks, if the ground lamps are disconnected.
East St. Louis, Ill. A. H. SUMMERS.

Building Maintenance and Plant Safety



The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Installing Many Individual Coolers Instead of General Ventilation

AN EFFECTIVE and unique ventilating system, which is installed in a bank in New York City, for supplying cool air directly to individuals in a spacious area, may be suggestive of some industrial applications, especially where it is more desirable to discharge the air near a worker than openly in the building, as is done by fans and ordinary ventilating pipes.

In the basement, just outside of the large deposit vaults, a blower fan, which is driven by a 3-hp., direct-current motor, is bolted to a concrete foundation. The blower draws fresh air from the outside of the building through an intake pipe located about 2 ft. above the walk. The open end of this pipe is covered with a fine wire gauze. A 4-in. galvanized iron pipe, with air-tight soldered joints, is carried from the 20-in. fan along the ceiling and up through the floor above to the rear of the partitions in the bank room itself. Here the pipe branches to a smaller size and is carried to the right and left along the floor at the lower edge of the partitions around three sides of the room.

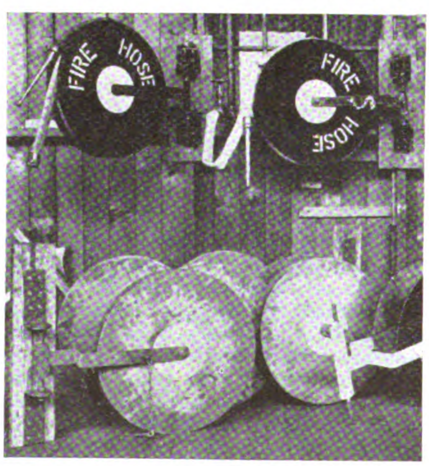
At every employee's desk and at every window a 1-in. tin pipe, similar to speaking tube, with joints tightly soldered, is carried upward from the floor. By means of a slide at the end of each pipe the amount of air can be readily regulated. As the 1-in. pipes are branched off the main distribution pipe is reduced in diameter. The pressure is just enough (I do not recall the exact pressure) to cause a steady, noiseless flow of cool air to pass out of the nozzles. On a warm, summer's day the whole room is perceptibly cool, yet no fans or other contrivance for cooling the place are visible to the patrons.

This method of supplying cool air is well liked by the employees because it is no trouble to them, and the air can be regulated by each individual to suit himself. On a warm day the janitor starts the motor and lets it run until closing time.

New Britain, Conn. H. S. RICH.

How Steel Hose Reels Reduce Maintenance Costs

HOSE reels as ordinarily used in industrial plants are made of cast-iron and are easily broken by bumps if they are located in or near a crane runway where there is trucking and handling of materials. This problem of how to prevent this breakage has been solved by F. J. Heuring, Bureau of Safety and Plant Protection at the Michigan City, Ind., plant of The Pullman Company. Here cast-iron reels for 1¼-in. fire hose, are, when broken, replaced by reels constructed of steel which can easily be straightened or repaired in case of a bump. These reels are made up of No. 10 gage steel on a 3-in. wood roller with a ¾-in. pipe through the center to serve as an axle. Center plates 10 in. in diameter and made of the same gage stock are riveted on each side of each of the two plates to give the reel additional rigidity and allow for connection with the ¾-in. threaded pipe used as an axle. The reel is suspended from the wall or post by an arm of ¾-in by 1¾-in. bar steel on a pivoting bracket, as may be seen from the illustration. Steel used in the construction of these reels is practically all taken from miscellaneous scrap materials.



When a cast-iron hose reel is broken, it is replaced by one of these special steel reels.

New York, N. Y. G. F. H.

Advantages of Proper Design in Floor Arrangement

THE columns in a building afford a convenient anchorage for partitions—in fact, so convenient that often the load-carrying capacity of the floor is seriously reduced by reason of the load being practically concentrated in the middle of spans.

A short time ago I was called upon to report on the condition of a building used for light manufacturing. The ground floor contained the machinery, and the second floor the stockroom and parts storage. The building construction was of the "combination" type; brick walls, cast-iron columns, steel girders, and wood floor-beams and flooring. The span of the girders and beams was 20 ft. The girders were 20-in., 65.4-lb. steel I-beams, while the floor beams were 6-in. by 16-in. yellow pine, spaced 5 ft. apart. Under a fiber stress of 1,200-lb. per sq. in. in the floor beams the allowable loading was 100-lb. per sq. ft. of floor area. The steel girders (with the usual 15 per cent reduction of assumed floor load) would permit a load of 180 lb. per sq. ft. Designing the floor beams for a load of 100 lb. per sq. ft., and the girders for a load of 180 lb. per sq. ft. (or the reverse), is an inconsistency which is frequently met.

The occupants of the building were concerned about its safety because of

the "springiness" of the floor. While the floor was a little overloaded in spots, there was no cause for alarm, although the owner's desire to add to the load could not, of course, be granted without arrangement.

An estimate was made of the loading imposed by the various bins and racks, and a layout of the floor drawn up. By placing the racks containing heavier materials over the girders, and building them up to the ceiling, also arranging the stocks of bins so that aisles and partitions occupied the middle of spans of floor beams, the capacity of the entire floor was more than doubled. At the same time more room was provided for trucking. The bins and racks placed over the steel girders were built solidly along the line of the columns and up to the ceiling. This construction imposed a shearing load on the column brackets and contributed little to the bending-moment on the beams.

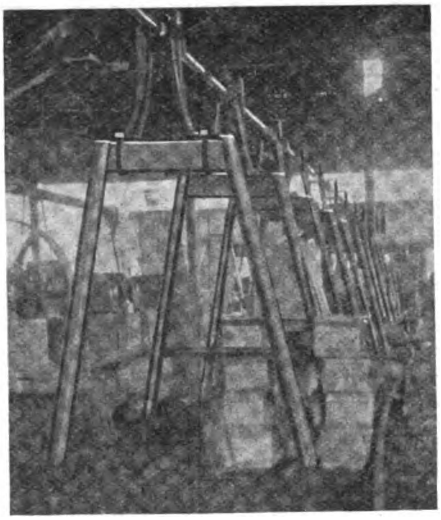
All jobs of any importance should be laid out to scale on paper. Too frequently jobs of the kind described above are left to carpenters, simply because the job involves woodworking, and the result is often unsatisfactory because the carpenter could not give the best answers to the problems involved. All jobs must be designed somewhere. When designed on paper, changes may be made in a few minutes by the aid of eraser and pencil. When the job is designed "in the field," changes are made only at an expense in materials and labor. Probably everybody has watched the progress of "field designing." One or two men mull over the advantages and disadvantages of several ideas, and several other men stand about waiting to carry out the verdict. Generally the owners, or management, are responsible for this condition because of the erroneous idea that the trained designer is too expensive. However, when building alterations, or the proper distribution of loads is being considered, good advice is worth all, and more, than it costs.

Kansas City, Mo. C. O. SANDSTROM.

Support for Shafting and Pipe Lines Made of Welded Pipe

PRACTICALLY every concern with a welding outfit is familiar with the many welding applications possible in the miscellaneous construction work around an industrial plant. The accompanying illustrations show two such applications which may be of interest to other industrial concerns. The illustration at the left shows how a lineshaft was supported on a framework or bent built of pipe and short lengths of I-beams. Here, it was necessary to install the lineshaft at an elevation which could not be conveniently reached by shaft hangers suspended from roof trusses. These bents are rigidly supported in concrete footings.

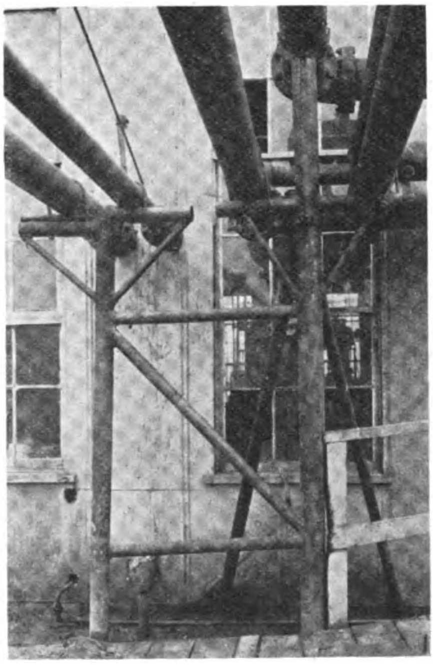
The construction of the joint by which the top horizontal I-beams were connected to the inclined posts is given as follows in some recent literature is-



These frames for supporting lineshafting and hangers were made by welding pipe to an I-beam crosspiece.

sued by the Linde Air Products Co., New York City. First, a slot shaped like an inverted "T" was cut in the top of each post with the cutting blowpipe. This was made sufficiently wide and long enough so that the end of the I-beam could extend into the pipe. The bottom flange of the "I" rested on the bottom of the horizontal part of the slot but the top flange of the beam rested on the end of the pipe. The beam was then welded to the pipe posts at all points of contact.

I-beams were used as top horizontals to provide a flat bearing surface for the cast-iron pillow blocks which were attached by means of U-bolts. The final lining-up was done by shimming up between each pillow block and its support. These bents were not only strong and neat but were made at a very low cost.



Another type of special support for pipe lines built up by welding scrap pipe.

The other illustration shows how a support for an irregular pipe layout was made through a special welded construction.

Making Permanent Markings for Lining Up Aisles

ALTHOUGH it is the usual custom to paint a white stripe on the floor in industrial plants to mark the location of aisles, these stripes frequently become defaced particularly on wooden floors where heavy castings and machine parts are moved around frequently. So that it will not be necessary to lay out this aisle location each time new markings are necessary, one company has nailed large metal disks to the floor along the edge of the aisle about every 10 ft. With these disks it is easy to find the line of the aisle even though it has practically been defaced by the trucking and wear of the castings. Also, the aisle can easily be lined up again by eye when painting from tack to tack.

Binder for Patching Concrete Floors Worn by Trucks

THE first step in repairing concrete floors worn into ruts from trucking is to cut away the top dressing, which is usually about 2 in. thick. A good tool for this is made as follows: Take a piece of 1½-in. hexagonal steel, about 2 ft. long, and put a diamond point chisel on one end, about 1½ in. long. This tool should be made as hard as possible and still not too brittle. With this tool and a 15-lb. hammer, the concrete top dressing can be easily broken away.

A common cold chisel proves satisfactory for trimming around the edges of the hole. Another good tool for this purpose is a mason's brick chisel. This is made of a piece of ¾-in. steel, about 6 in. long; 4 in. are used for a handle and the other 2 in. is drawn out flat, forming a blade about 2 in. long and 3½ in. wide.

All surfaces must be cleaned thoroughly and all loose material removed from the opening. Before placing the patch it is necessary to supply a binder so as to get a good union between the old and new cement. In our plant Iron-Stone Welding Cement (Stone Tar Products Company, 97 South Sixth Street, Brooklyn, N. Y.) is used. This is a white powder resembling plaster of paris and is mixed with water to the consistency of thick cream and applied with a brush. It is not necessary to dampen the old cement as the binder takes care of that. The entire surface of the old cement should be covered with the mixture and new cement poured when the binder is nearly dry.

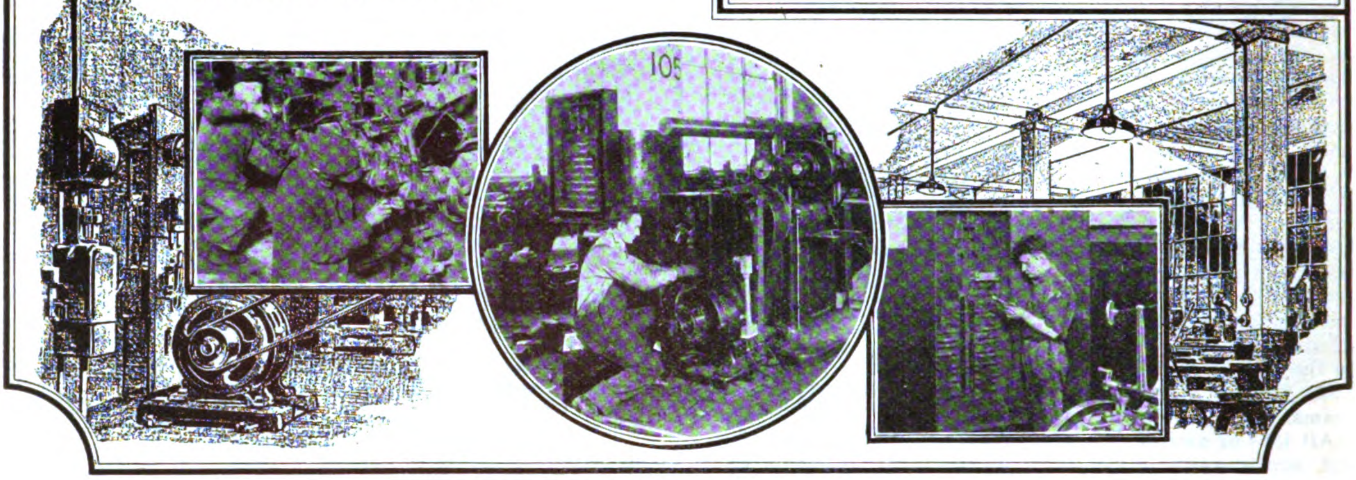
The top dressing patch is made of a mixture of one bag of cement and two wheelbarrows of sand. After the concrete patch is poured, it should be allowed to stand for about 2 hr. until it begins to dry. The surface should then be trowelled in the same manner as any cement floor.

American Chain Co., Bridgeport, Conn. D. FLIEGELMAN.

Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Safety Clamp for Locking Compensator to Prevent Starting of Motors

THE use of locks as a means of locking safety switches and other control devices is becoming more widespread. In the accompanying illustration is shown a method of locking the handle of a compensator in the off position, thereby preventing any one from starting the machine controlled by the compensator until the lock is removed from the clamp. Locks are provided for the operator of the machine, the electrician, and any other maintenance men, so that in case any or all of them are working on either the electric lines or any part of the machinery connected with the starter, they can safeguard themselves by locking the starter in the off position with their padlocks. Many accidents and near-accidents have been averted through the proper use and installation of this lock.

The locking clamp is made from No. 10 gage sheet steel. A hole is punched in one end of it of a size that will slip over the handle of the compensator. A slot about ¼-in. wide and 4 in. long is made in the other end to take the end of the bracket which is bolted to the compensator case. This bracket is made of No. 10 gage sheet steel and has three ½-in. holes drilled in it to permit the use of three separate padlocks. If it is likely that more than three padlocks will be used simultaneously to lock this compensator, more holes may be provided in the bracket. One end of a piece of chain is fastened to the locking clamp and the other end of the chain is fastened to the bracket cap screw. This is to prevent the clamp from being mislaid when the lock is not being used, as is shown in the right-hand illustration.

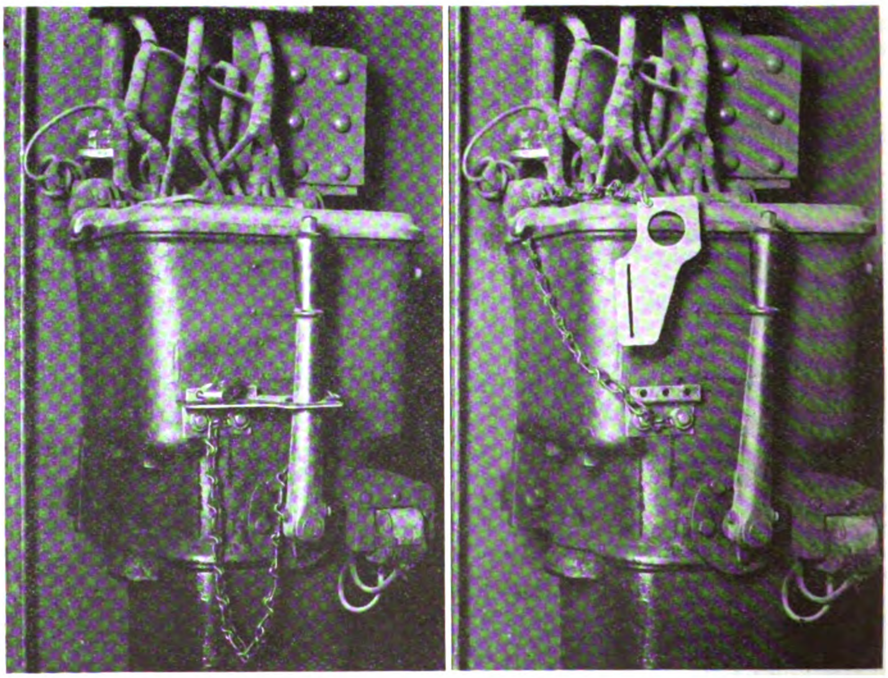
GEORGE E. WALLIS.
National Safety Council,
Chicago, Ill.

Method of Arranging Conductors to Indicate Voltage

IN HIS paper on safe operating practice with regard to electrical devices, presented at the Safety Congress recently held at Louisville, Ky., G. F. MacWilliams, electrical engineer of the Pennsylvania Coal & Coke Corporation, Cresson, Pa., spoke as follows of the necessity of having some system of identification of conductors carrying different voltages, so as to protect the maintenance men working on them.

In laying out a new wiring installation all conductors should be arranged so as to indicate to the workmen the pressures of the different wires. Colored cables and conductors, also insulators and supports, may be used to indicate the pressure of the conductors. In plants where many different circuits are laid out together, it is possible sometimes to arrange those conductors carrying the highest voltage in places where they will be safest. In some installations it may be possible to locate conductors carrying high voltages on the uppermost arm or rack of the supporting structure.

When using insulated wires it is well to use only conductors having an insulation which, under nearly all conditions, could never become dangerous. If this cannot be done, bare wires should be installed as they can in no way convey to the workmen a false idea of security. Many people have been injured by mistaking weatherproof wire for insulated wire. The



These clamps are easily made from sheet steel and will save their cost many times over in accidents averted.

These two illustrations, furnished by the National Safety Council, show how the clamp is attached to the compensator and the method of using it.

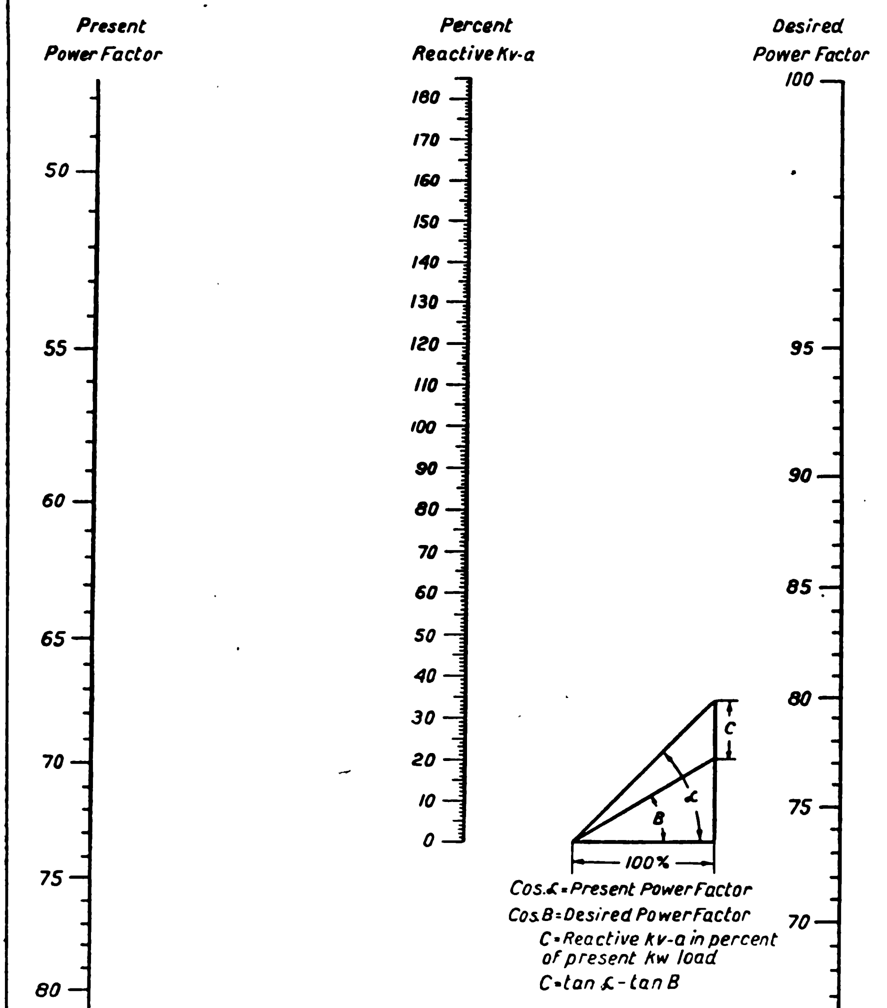
number of such accidents would have probably been much less had the wire been bare. All cable sheaths and conduits, carrying conductors, should be grounded. Metal tags may be placed on cable sheaths indicating the voltage carried by the conductors, also end bells or potheads should be plainly marked. All cables or wires should receive a test of two and one-half times their working pressure soon after being installed.

Chart for Finding Kva. Required to Raise Power Factor to Desired Value

DETERMINING the corrective kva. required to raise a certain load from one power factor to a higher power factor is a tedious process when done mathematically. The accompanying chart, which was taken from a booklet entitled "Starting Condensers for Power-Factor Correction," published by the Westinghouse Electric & Mfg. Company, performs the desired calculation almost instantly.

Assume that it is desired to determine the corrective, kilovolt-ampere capacity that is required to raise a 100-kw. load from 65 per cent power factor to 85 per cent power factor. On the left-hand scale (marked Present Power Factor) of the chart find the figure representing the present power factor, that is, 65 per cent; on the right-hand scale find the figures representing the desired power factor, which is 85 per cent. Join these two points by means of a straight edge and from the center scale read the reactive kva. in per cent of the present kilowatt load required to correct from one power factor to the other. This percentage is 55. Now multiply the kilowatt load by this percentage to get the corrective kva. required; that is, 55 per cent of 100 kw. equals 55 kva, which is the corrective capacity that will be required.

The small diagram in the chart shows how the chart was prepared. The base of the triangle is taken as 100 per cent and represents the present kilowatt load. The present power factor is represented by the cosine of the larger angle; that is, cos α and the desired power factor is represented by cos β. The reactive kva. with the present power factor is represented by the vertical side opposite the angle α and is equal to tan α. Likewise the reactive kva. of the desired power factor is represented by tan β. The reactive kva. required to raise the present power factor to the desired power factor would, therefore, be represented by the difference of the tangents of the angles and is shown at (C) in the diagram.



To find the "per cent reactive kva." necessary to raise the present power factor to any desired figure, place a straight-edge connecting the corresponding values in the outer scales of the chart. Read the reactive kva. in per cent of the present kw. load on the middle scale. Copyrighted by the Westinghouse Electric & Mfg. Company.

Method of Fishing Complex Bends Through Flexible Steel Conduit

THE method which was used to overcome the difficulty in fishing wire through flexible conduit on a special job may be of interest to readers of INDUSTRIAL ENGINEER.

A headlight turbine generator was put on one of the locomotives of a small branch line railroad and it was necessary to install lights inside and a headlight on the end of a passenger coach. The wiring was all in conduit and because of the spiral ribs in the flexible conduit it was impossible to get a fish wire around some of these bends, which were numerous and complicated, although the wire had a closed loop on the end and was twisted and maneuvered in every way for a long time.

Finally, the fish wire was taken to the shop and a No. 18 copper wire was wrapped a number of times around the loop and then tinned and soldered. After this, it was dressed down with a file until a ball about ⅜ in. in diameter was formed at the end of the fish wire. By pushing and twisting, we were eventually able to get the fish wire through the flexible conduit. It was then a comparatively simple matter to draw the conductors through also. However, the ball on the end of the fish wire really did the trick.

Oakland, Calif. S. H. SAMUELS.

Securing Maximum Service from Induction Motors

HOW to get maximum service out of induction motors is something that many users do not fully understand; nor is all apparatus for starting and protecting such motors designed to allow them to give the best performance and still protect the motor against harmful abuse. Unlike other types of motors, there is no chance of sparks being thrown from the standard squirrel cage induction motor so commonly used for all kinds of drives, until a wire or lead actually shorts or breaks, which takes some time under the severest conditions, and is preceded by considerable smoke. Overloads of short duration even to the point of stalling the motor under full-line voltage do not hurt a good standard make of induction motor if it is released in time or else cut off the line entirely, should it remain stalled, before the

winding has time to heat enough to injure the insulation. Throwing such motors on full-line voltage when standing still or even reversing them under full-line voltage does not seem to do any harm to a good machine of less than 50 hp. rating, nor to larger machines if the coils are well bound or supported. With a hand starter or compensator where the motor is disconnected when changing from the starting to the running side, as is the case with most starters, the oscillograph shows under certain conditions a higher current for one or two waves than it would show when the same motor is thrown on the full-line voltage when standing still. Such high currents have a tendency to rack the coils or twist them, but on all good, small and medium-sized machines the coils are supposed to stand such a stress.

Unlike direct-current machines a starter would not be necessary to start an induction motor or protect it from injury in starting, but it is necessary in order to make motors start smoothly, thus giving the driven machinery time to start and preventing the line voltage from dropping by allowing the motor to draw only a fraction of the current it would draw if it were thrown directly on the line when standing still.

While I would not advise anyone to abuse any motor unnecessarily thus, I am mentioning this in order to strengthen some other points that I wish to bring out in this article.

When properly cared for an induction motor will stand considerable abuse in the way of overloading. For example, an induction motor that is rated at say, 10 hp., with 25 per cent overload for two hours, will carry 10 hp. continuously with not more than 40 deg. C. rise in temperature and while so running and heated to that temperature will stand an overload of 25 per cent more for two hours before reaching a temperature 55 deg. C. above that of the room, providing that the motor is clean and the ducts open so as to afford proper ventilation. When all the ducts are filled with dirt proper ventilation is impossible and the machine may even be insulated against radiation, as is so often the case, and the user does not understand why his motor burns out and requires rewinding occasionally. Where these machines are in very dusty places they should be well cleaned with compressed air to keep the ducts open or else placed so that the dirt and dust are kept out, if the full rating is to be expected of them.

From my experience in looking after such motors in different manufacturing plants I have found that few of them have a constant load, nor is the user getting the best service out of his motors. There is oftentimes a tendency to get a larger motor than is required to carry the load. This is expensive all around. The extra power consumed in running a larger motor than necessary is quite an item when the motor is used continuously, but more than that the power factor of the line may be greatly reduced by such a practice, calling for higher rates from the power company. Where the load varies greatly or there are high peaks the starter should not release the motor for several seconds under any overloads because very often these are of such short duration that they can do the motor no harm if sufficient time is allowed for it to cool off for the next high peak. A motor so operating can without any harm carry all it will pull, which is usually over twice its rated capacity plus its momentum as it slows down in speed, if the protecting relays are properly designed. Automatic starters have a great advantage over hand-operated starters in that their protective devices can act to protect the motor under all conditions, starting as well as running, which is not true of most hand-operated starters where the handle can be held and the motor subjected to abuse in spite of the protecting devices. Also, automatic starters always give the motor the proper time in which to start and on account of the quick action of their mechanism the contacts are subjected to much less burning than is the case with hand-operated starters.

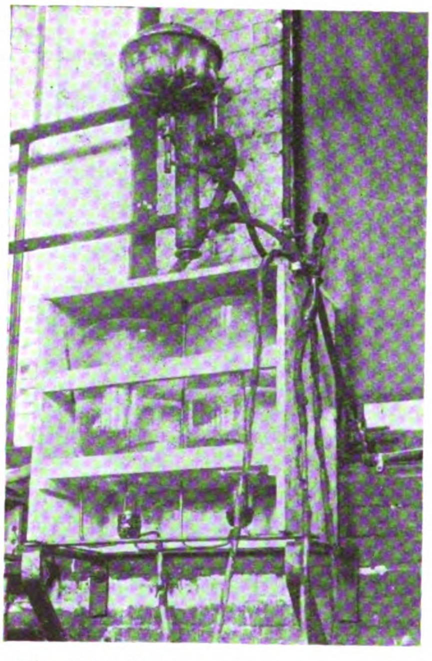
PHILIP G. BERNHOLZ.

East Orange, N. J.

Convenient Arrangement of Water Still and Storage Bottles

WHERE not over seven or eight storage battery tractors are in use, a still for supplying the distilled water needed can be put in without great expense and will be found very convenient. In one plant the arrangement of still and water storage bottles shown in the accompanying illustration has been installed and is giving very satisfactory service.

As will be seen, the still is mounted on the wall directly over the two water storage bottles which are of 5-gal. capacity each. A plank 2 in. thick, 12 in. wide and 24 in. long supports the bottles which are inverted and rest in chamfered holes. This shelf in turn is supported on ¼-in. by 1½-in. iron brackets fastened to the wall by expansion bolts. For protection, the bottles are enclosed on the ends and top by a box-like wooden frame, which has a strip nailed across the front to protect the bottles and keep them from falling in case they should tip.



The still is mounted directly over the bottles in which the distilled water is stored and drawn off into the storage batteries as needed.

Two ¼-in. copper tubes are led into each bottle through the corks, which are tied in position and covered with sealing wax. One of the tubes serves as an air vent and on the inside of the bottle reaches nearly to the top. On the outside, these tubes extend slightly above the top. The other two tubes, which project only two or three inches above the cork, are joined together by a Tee fitting, the side outlet of which is connected to another length of copper tubing which is attached to the bottom of the still and serves to convey the distilled water from the still to both bottles at the same time.

Water for filling the batteries is drawn off through a short piece of copper tubing inserted through the cork of the left-hand bottle. This piece of tubing is clamped to the wall to avoid putting strain on the other tubes. To it is attached the rubber tube which terminates in the battery filler. The water inlet tube which is common to both bottles also acts as an equalizer and maintains a constant water level in both.

When installed, the highest part of the bottles was placed 5 ft. above the floor to insure a good flow of water into the battery of the tallest truck, which is about 4½ ft. high.

The alarm is placed close by on brackets, with the dry cells, relay and bell enclosed. The leads are carried to the nozzle tip where contact is made and the alarm sounded when the solution in the cells reaches the proper height.

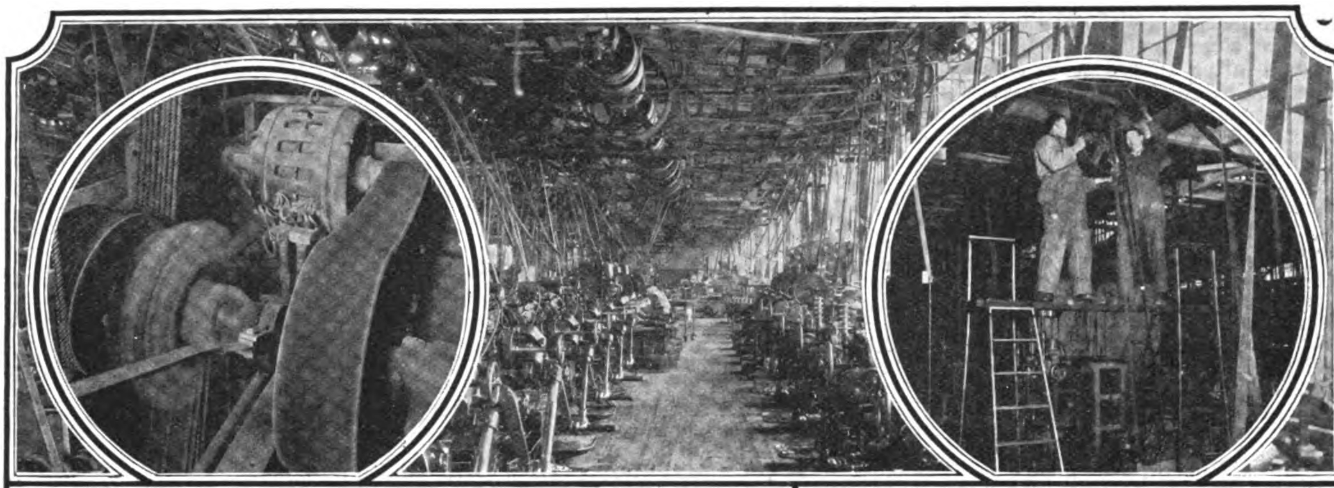
With this type of still a steady stream of cold, city water is kept flowing through the condensing column and out of the discharge pipe. About ½ in. depth of water remains in the upper receptacle where it is boiled by a bunsen burner directly below. In case the water is allowed to flow too fast, an overflow outlet leads it away and discharges it into the sewer.

Intake of water and gas can be closely regulated and when the still is working properly, a steady, small stream of distilled water flows out at the bottom.

This outfit will fill the bottles to capacity, about 10 gal., in 15 hr. of steady going, which means that about 7 gal. can be produced from 7 a.m. to 5 p.m. This is sufficient to supply seven or eight tractors using Edison batteries which must be watered every day when worked rather hard and steadily.

The still was secured from the S. J. Stokes Machine Co., Philadelphia, Pa., the bottles from a drug store, the rubber and copper tubing from a hardware store, and the alarm and filter nozzle from the Edison Storage Battery Co. The shelves and brackets were made up in the shop.

Jamestown, N. Y. H. S. RICH.



Mechanical Maintenance of

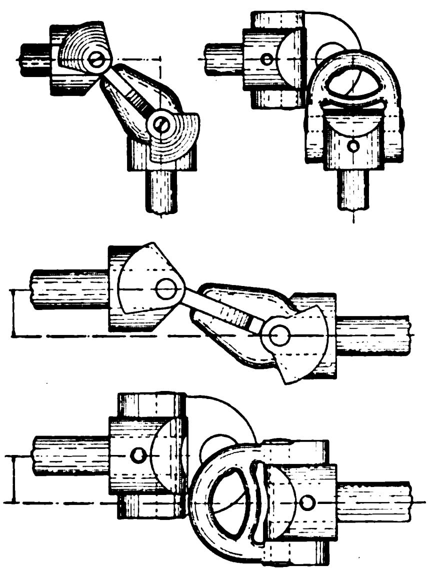
Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Driving Shafts at Right Angles With Special Transmission

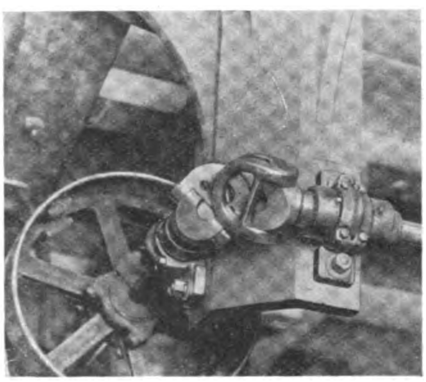
ORDINARILY where shafts must be driven at an angle, it is necessary to use bevel or miter gears, or if the connection is to be by belt, through a mule stand. Under ordinary conditions bevel or miter gears are rather noisy. In addition, it is essential that the shafts be in the same plane and not offset.

Where a 1 to 1 angular velocity ratio is desired, it is possible to use the special Bartlett angular transmission, even though the shafts be at a right angle to each other, as is shown in the accompanying illustration. When used as right-angle drives for lineshafting special hangers, with self-aligning, ball-bearing hangers and oil cases, are recommended. This drive is attached to a 1 7/16-in. shaft which has a full-load rating of about 3.43 hp. per 100 r.p.m. The maximum speed of this size of coupling is 465 r.p.m. This drive operates in an oil case which consists of an upper and lower half which telescope into each other. The lower half is secured to the hanger. Bearings of the self-aligning type, combined with the flexibility of an angular drive, permit the transmission to be placed directly at the shaft end even though the two shafts do not lie precisely in the same place.



These drawings show how the angular transmissions operate under conditions of angular and offset misalignment.

How this drive operates for connecting to shafts at an angle and also in case of misalignment, is shown in the two accompanying sketches. These drives are made in nine sizes to be used on shafts varying from 7/16 in. to 2½ in. in diameter and are capable of transmitting from 0.10 hp. to 12.5 hp. The speed ratings of the smaller size are 1,850 r.p.m. maximum and on the larger size 250 r.p.m. maximum.



Making a right-angle drive on a lineshaft.

Here two 1 7/16-in. lineshafts are connected at right angles through a special Bartlett angular transmission (G. M. Bartlett, 2533 College Ave., Indianapolis, Ind.). This special drive, together with the self-aligning bearings enable the installation to operate even though it is not in perfect alignment at the ends of the shaft. This connection will transmit up to 3.43 hp. per 100 r.p.m. and has a maximum rating of 465 r.p.m.

Lubrication Methods For Motor Bearings Operating In Hot Locations

MOTORS are sometimes called upon to operate in locations subject to high temperatures produced by such equipment as induced draft fans on boilers, calcining kilns and the like. In instances coming to the writer's attention, the oil temperature in bearings of motors in this class of service was found to be between 160 deg. and 180 deg. F. during the summer months. About thirty 25-hp. motors were operated under this condition. The air temperature on the motor floor averaged about 130 deg. F., and the motors were located about 12 ft. from the induced-draft fans and ducts which handled gases at 650 deg. F. The temperature of the motor frame was always a few degrees lower than the oil temperature and the rise above air temperature was due to the heat radiated from the surrounding 650-deg. F. bodies and by the conduction, through the frame, of the heat generated in the winding.

Particular attention was paid to ventilation of the building in order to keep as low an air temperature as possible. The motors were of 25 per cent greater capacity than required by the load in order to keep the winding temperatures within safe limits and to reduce the heat which could be conducted to the bearings. In the original installation several 900-r.p.m., 30-cycle motors were installed, but observation soon proved that the bearing wear and failures were excessive and conditions could not be improved very much with that speed of motor. In later installations standard 600-r.p.m., 25-hp. motors were used with bearing shells about 1 in. longer and ⅝ in. larger in diameter than on the 900-r.p.m. motors. This, together with the lower operating speed, increased the life of the bearings to the normal figure for motors in the rest of the plant. All bearings had standard cast- or wrought-iron shells, were bab-

bitt lined and ring oiled. Many of these bearings were replaced with a full bronze bearing turned from cored bar stock, and these gave very satisfactory performance especially in reducing the number of burned-out windings due to the babbitt melting out of the shell, which allowed the rotor to rub the iron of the stator. The disadvantage of a bronze bearing lining is that when it becomes overheated and "seizes" the shaft the latter is usually scored and necessitates turning down. After a few such turnings a new shaft is required. This, however, must be balanced against the cost of a new winding when the babbitt bearing fails. When the winding is undamaged a spare rotor with end bells and bearings, may be quickly substituted in the stator after a bearing failure.

The secret of successful operation of either the bronze or babbitt type of sleeve bearing rests upon the type of oil used and the man who oils the bearing. As grades of any given oil seem to vary from year to year it would not be safe to specify any one oil as being the best and many serious "runs" of bearing failures on these drives described have been traced to a new batch of oil of the same grade, or of a new grade having the same "characteristics," according to the maker. As a rule the class of oils known as machine oils will yield a satisfactory oil after some experimenting. The viscosity does not necessarily have to be high but rather should be as uniform as possible over a wide range of temperature. It should have the body and tenacity to cling to the ring in good quantity up to an oil temperature of 180 deg. F. Some oils become as thin in consistency as kerosene at this temperature and the bearing will run dry with a full oil well. A thick oil of the "cylinder oil" class is too heavy when the motor has been shut down some time and the oil allowed to cool. Then, the ring will hardly turn when the motor is started up and a burned out bearing often results; this may be overcome in a degree by mixing the "cylinder" and "dynamo" classes of oils to the proper consistency so that the oil ring will revolve freely when the mixture is at the air temperature of the motor room. This method depends on the personal element entirely too much and it is always better to search for the proper oil which will work under a fairly wide temperature range and so eliminate one more variable or source of error which may cause trouble.

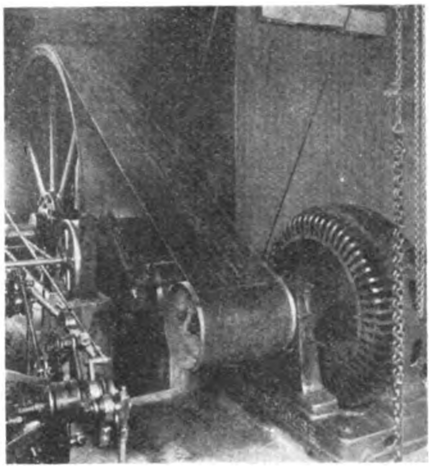
As mentioned before much depends on making a careful selection of the proper type of man for oiler. A settled, middle-aged man who is conscientious should be selected and the wage proportioned to the importance of the job. A young man who is energetic and restless is not the type of man for a particular oiling job which is a monotonous routine of watchful waiting to detect the first sign of overheating. Where dust and heat are both present the bearings should be oiled and inspected twice each day. Where the temperature is so high a bearing which is "overheated," relatively speaking, may be detected by the quantity of oil necessary to replace the evaporation. Best results are obtained when the bearing is flushed and oil replaced with new oil once a week.

J. ELMER HOUSLEY.

Electrical Engineer,
Aluminum Company of America,
Alcoa, Tenn.

Changing Group-Drive Plant to Individual Drive

OPERATING men in plants with an engine-driven lineshaft may be interested in the following account of how a similar installation was transformed to electric drive without interruption to normal operation. Here an 18-ft. flywheel drove a 6-ft. 6-in. pulley on the lineshaft through a 26-in. double leather belt. The generator and the Lenix drive were erected while the old drive was still in operation, as it did not interfere.

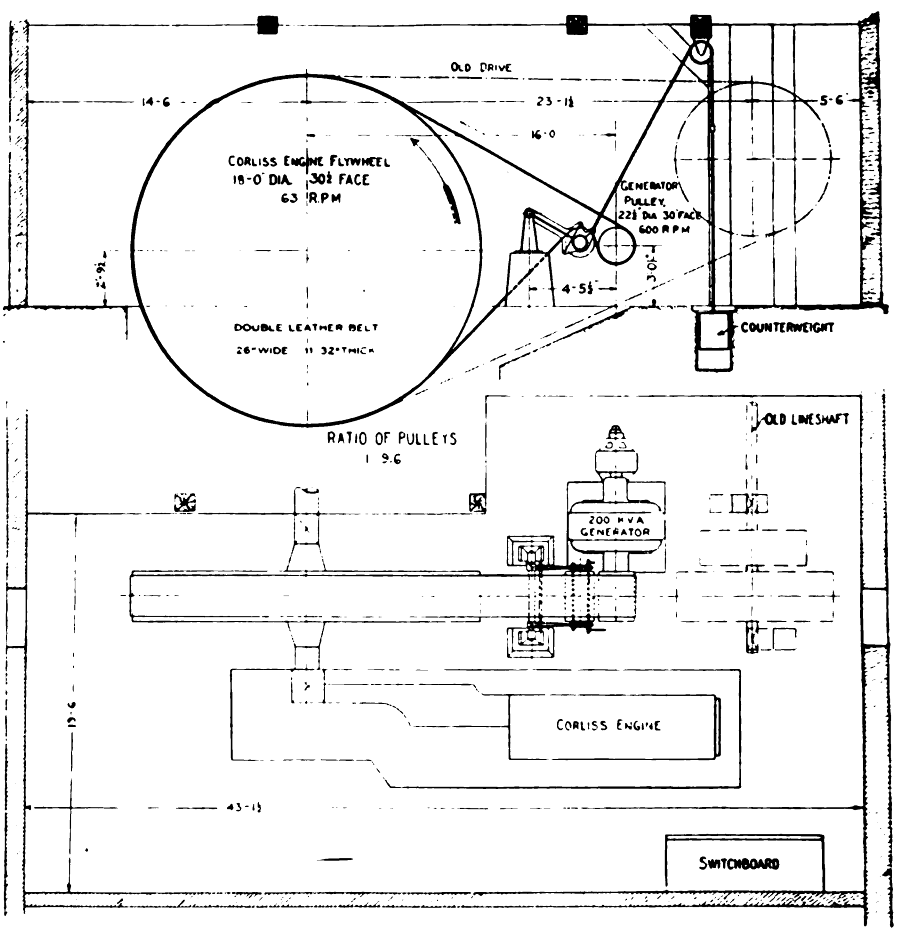


This shows the compact arrangement of the drive for an engine-driven generator shown in the accompanying sketch.

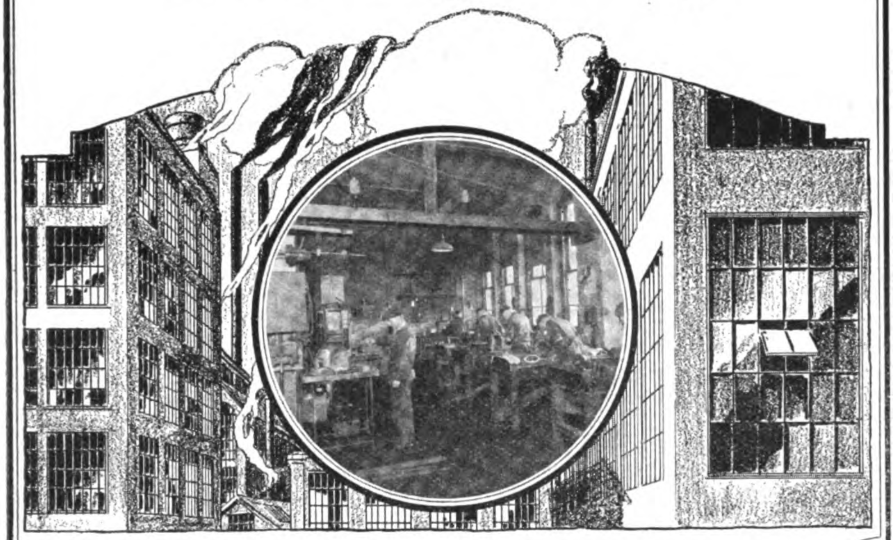
On the first Saturday afternoon after they were installed, the old belt was cut, spliced and fitted to the 200-kva. generator, shown in the sketch and also in the accompanying illustration. The entire new system was tried out on Sunday morning for a few hours to see that it operated satisfactorily. In the meantime, the lineshaft had been divided into sections that were connected up to electric motors; some of the machines were provided with individual drive so that on Monday morning, the entire plant operated with a mixture of group and individual drives, with no interruption of production.

The pulley ratios at the engine flywheel and at the generator are 1 to 9.6 and operate on 16-ft. centers. This permits the generator to operate at 600 r. p. m. whereas if it were not possible to get such a high pulley ratio, a low-speed generator would have to be used which would have cost considerably more. When the equipment is idle over night and on Sunday, the counterweight which gives the increased arc and maintains the tension is raised so as to relieve the belt tension and accordingly lengthen its life.

This sketch shows how the generator was placed in line with an engine drive so that the equipment of the plant could be motor driven instead of operated from an engine-driven lineshaft.



In the Repair Shop



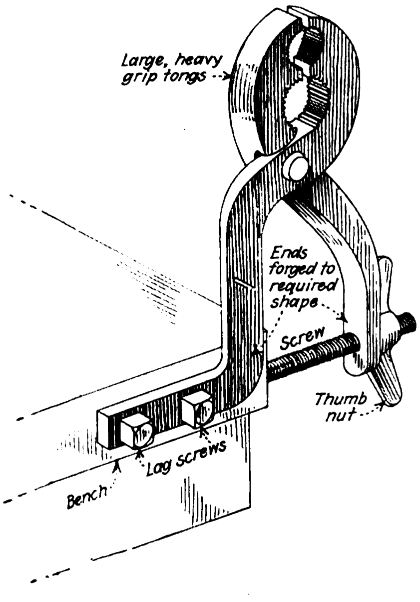
This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Easily-Made Grip Tongs Used as Vise for Holding Small Work

A SIMPLE and easily-fashioned but very serviceable tool was made from a pair of grip tongs and is in daily use at one repair shop. As will be seen from the illustration, one handle of a large pair of heavy tongs was forged flat and bent at a right angle so that the tongs could be fastened to the side or end of the bench with two lag bolts. The other handle of the tongs was slotted to permit passage of a long screw, one end of which is screwed into a small plate which is firmly fastened to the edge of the bench. The end which passes through the handle of the tongs is fitted with a thumbnut so that the tongs can be firmly closed like a vise around any desired object.

The variety of work which this fixture will handle is very wide, as it can be used for holding pipe, round bar, pieces which are being filed, drilled or cut with a handsaw, and so on. It has also been found very useful for gripping cable or rope while splicing. Altogether, this simple tool replaces or is the equivalent of a vise, at a considerably less cost.

Washington, D. C. G. A. LUEBS.



The tongs are mounted on the bench and fitted with a long screw and thumbnut for closing them tightly around pipe or other work.

How to Test Lap-Wound Armatures with Equalizer Connections

REPAIRMEN are sometimes in doubt as to the proper procedure when testing lap-wound armatures with equalizer or cross connections. However, if the principle of the equalizer connection is clearly understood, the problem is quite simple. The fundamental principle is that points on the armature that are of the same potential and polarity are connected together. On a four-pole machine these points will be 180 deg. apart, on a six-pole, 120 deg., on an eight-pole, 90 deg., on a ten-pole, 72 deg., and so on. There are a number of ways of putting the equalizer connections on. In one method rings are used either behind the commutator or at the rear of the armature winding. Another method makes use of the two-layer, one-turn open-end coil, either diamond or involute type of winding.

The minimum number of rings is equal to one-half the number of poles, and each ring must have $P \div 2$ connections or taps to it, where (P) equals the number of poles.

Then for a four-pole machine the minimum number of rings would be two and each ring would have two taps or connections to it. The connections on ring (1) would be 180 deg. apart or on the half; the connections to ring (2) would also be 180 deg. apart, but the spacing between the taps to rings (1) and (2) would be 90 deg. Assume a four-pole armature having twenty-four slots and bars and two equalizer rings. The pitch between taps on each ring would be $24 \div 2 = 12$, or bars (1) and (13), and the spacing between taps to rings (1) and (2) would be $24 \div 4 = 6$ or bar (7); the second tap to ring (2) would be bar (7) plus 12 equals (19).

The above brings us to the rule that governs ring-type equalizers: The number of rings (R) times the number of pairs of poles (S) must be a multiple of the total number of single coils (C). The total number of single coils is equal to the number of slots times the coils per cell. In the above, the expression "number of pairs of poles," is also equal to the number of taps required per ring; then the total number of taps (T) to all rings equals $R \times S$, and the spacing in single coils or bars between taps is $C \div T$. In many cases the number of rings must be selected to satisfy the above formula. For example, assume a fourteen-pole armature having 280 slots and 840 bars and single coils, three coils per cell. Now the minimum number of rings is $14 \div 2 = 7$, and the number of taps per ring is also 7 and the total taps would be $7 \times 7 = 49$. But $840 \div 49$ will not give even spacing. The multiples of 840 are 420, 280, 210, 168, 140, 120, 105, 84, 70, 60; then the least number of rings would be ten and with seven taps per ring, the total taps would be $7 \times 10 = 70$, and the spacing would be $840 \div 70 = 12$, or (1) and (13). The spacing on each ring would be $840 \div 7 = 120$, or bars (1), (121), (241), (361), (481), (601) and (721) would connect to ring (1). Then the connections to ring (2) would start at bar (13), the other bars would be (133), (253), (373), (493), (613), (733). Ring (3) would start on bar (25); ring (4) at (37); (5) at (49); (6) at (61); (7) at (73); (8) at (85); (9) at (97); and (10) at (109).

Per cent equalization equals $(T \div C) \times 100$, or in the above case $(70 \div 840) \times 100 = 8\frac{1}{3}$ per cent equalized.

The above will enable anyone to figure out the spacing of ring-type equalizers, which is important to know when testing, as will be shown later.

With the coil type of equalizer, the pitch between points will be $C \div S$ as before and the spacing will be $C \div E$ where (E) equals the total number of equalizers. The number of rings, taps or equalizers can easily be counted. If the connections are made at the back of the commutator, examine each commutator riser between the commutator bar surface and the bottom armature coil lead and a place will be found where the equalizer connections are soldered to the riser. When coil-type connections are used there will be a bottom and a top connection to each point except on four-pole machines. Thus the coil type of connection forms a ring, connecting the equipotential points together.

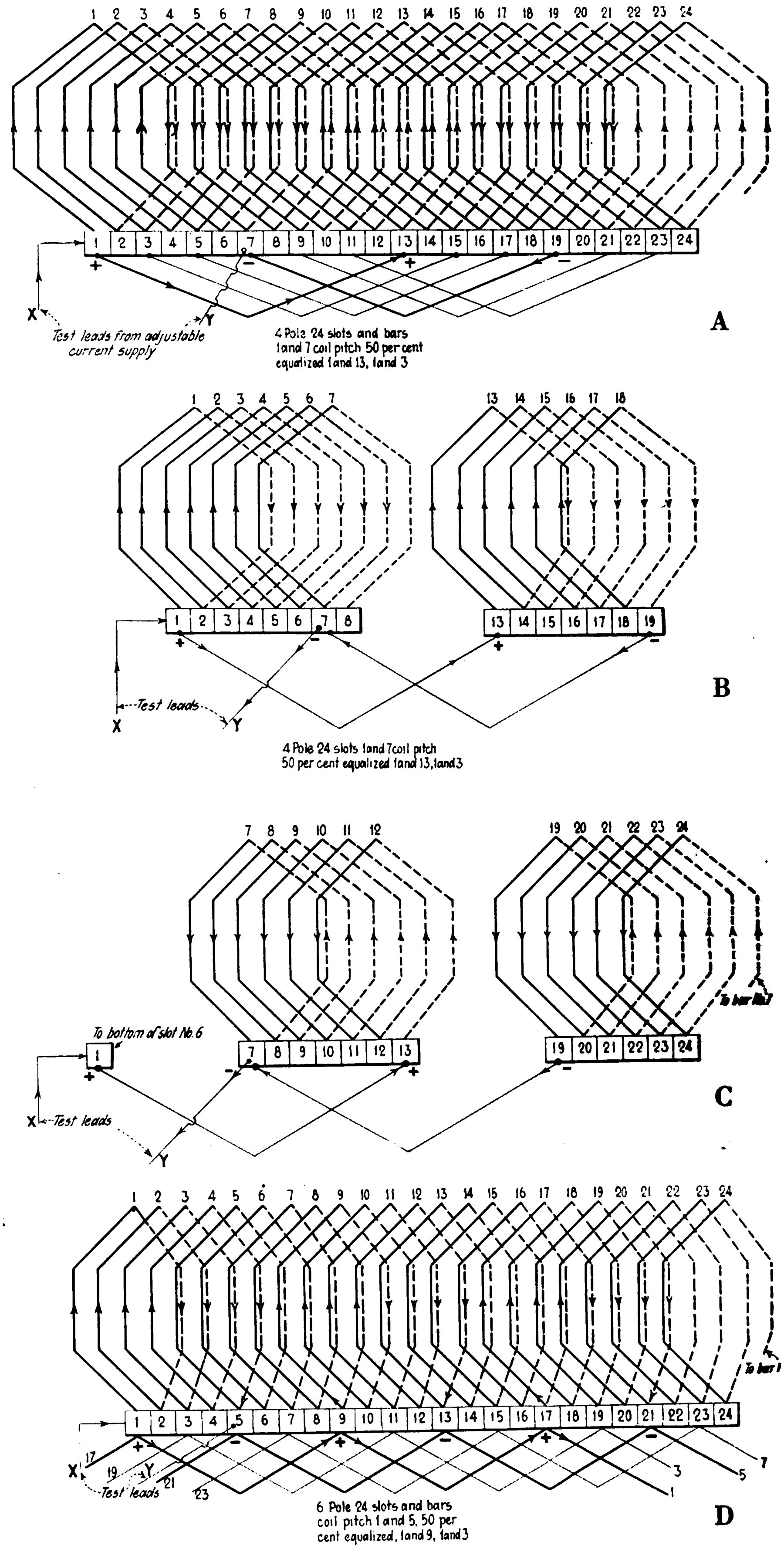
Now we can consider the testing of the complete armature using the bar-to-bar millivoltmeter test. The first step is to find the tap pitch C ÷ S and divide this by 2, or (C ÷ S) ÷ 2. Then place one of the adjustable, test current supply leads to bar (1) and the second test lead to the bar one-half the tap pitch away; this will supply current to all brush positions and the effect will be the same as if the armature were in the field and held from turning while current was supplied to the brushes. The current will follow its regular paths.

For example, take the case shown in (A) of the diagram. The tap pitch is 1-and-13, and half pitch is 6, or 1-and-7. Then if we place one current supply lead on bar (1) and call this a positive (ingoing) lead and the other or negative lead on bar (7) we will also supply current to bar (13) through the equalizer connection, and bar (13) will be positive. Likewise bar (19) will be negative, as it is connected to bar (7) by the equalizer. We can adjust the current so as to get a good scale reading when the meter is put across bars (1) and (2). The whole armature can be tested without removing the leads from bars (1) and (7), but when the meter leads are put on bars (7) and (8), we will get a reversed reading. This reading will be reversed until the leads are placed on bars (13) and (14); then it will return to normal and will read normal until bars (19) and (20) are reached, when the reverse reading will again be obtained. All positive readings can be obtained by putting the positive supply lead on bar (7) and the negative lead on bar (13), one half-pitch away.

Move the leads in this manner each time, being careful of the spacing. In diagram (B) are shown two of the paths through the windings with the supply leads on bars (1) and (7). The current flows from left to right, or through coils (1), (2), (3), (4), (5), (6), and coils (13), (14), (15), (16), (17), (18). Diagram (C) shows the other two paths from bars (13) and (1) right to left, or through coils (12), (11), (10), (9), (8), (7), and coils (24), (23), (22), (21), (20), (19). This explains why reversed readings are obtained on the meter.

Diagram (D) shows a six-pole armature with coil-type equalizers. Note that three connections form a closed circuit or ring, connecting together three equally-spaced points.

Then to test lap-wound armatures with equalizers of any type, determine the tap spacing, locate one bar to which an equalizer connection is made, put one test current supply lead on this bar and the other test lead on a bar one-half of a tap pitch away on either side of the positive test lead. For example, in diagram (D) use bar (9) for the positive and bars (5) or (13) for the negative lead. Then apply the millivoltmeter leads between these points, that is, to bars (1) and (2), (2) and (3), (3) and (4), (4) and (5). Then shift test lead (X) in diagram (D) to bar (5) and lead (Y) to bar (9), and test with the meter bars (5) and (6), (6) and (7), (7) and (8), (8) and (9). As before shift (X) to bar (9), (Y) to bar (13), and so on. Be sure to start on a bar that has an equalizer connection attached to it, and space the leads one-half of a tap pitch; also be careful



Current paths through and method of testing lap-wound armatures with equalizer connections.

to maintain this spacing throughout the test and do not interchange the test leads. This method gives consistent results if carried out as explained above.

A growler or bug can be used to good advantage in testing equalized windings. There is no danger of burning out shorted coils with the bug, as the closed circuit is formed through at least four coils on a 50 per cent equalized armature.

Pittsburgh, Pa. A. C. ROE.

Time Saving Method of Seating Carbon Brushes

THOSE who are familiar with the operation and maintenance of commutating machines well know the particularly unpleasant drudgery of "grinding in" a set of direct-current brushes by hand. The job is very tedious and takes considerable time. Brushes installed with flat faces, as received from the manufacturer, and not "sanded in" will require from four to five days to as many weeks with the machine operating at reduced load, to seat themselves properly. The length of time required depends primarily on the composition of the brush and the condition of the commutator.

A quick method of obtaining even better results than can be secured by grinding the brushes in with sand paper by hand is to coat a portion of the commutator with shellac and sprinkle very fine sand over the shellacked portion before it is dry. After the shellac has dried, a few minutes run of the motor or generator, as the case may be, will grind the brushes to a very good seat. The sand and shellac can then be removed by washing with alcohol.

Oakmont, Pa. A. W. MCAULY.

How to Determine Proper Length of Wrench for Use on Nuts

HOW often does it happen in tightening up nuts on some machines that the threads on the nuts or bolts are stripped? In tightening nuts, a pipe should never be slipped over the end of the wrench in order to increase the leverage. Wrenches should be selected that are short enough so that the nut will not be over-strained.

Tests made by the Crane Company, as published in *Valve World*, show that a compression of about 12,000 lb. can be obtained by one man using a 16-in. wrench on ¾- to 1-in. bolts, or by using a 36-in. wrench on 1⅛- to 1⅜-in. bolts, or by using a 60-in. wrench on 1½- to 1¾-in. bolts, or by using a 72-in. wrench on 1⅞- to 2-in. bolts. It was found that square nuts give from 20 to 25 per cent less compression than do hexagon nuts with a given effort on the wrench. Rough-cut or uneven threads will reduce compression 10 to 15 per cent. Lubrication of the thread and bearing surfaces will increase compression approximately 50 per cent over that which may be obtained with dry threads.

It is not necessary to over-strain bolts if proper wrenches are used, and if the correct length of wrench is employed it will be found almost impossible to over-strain bolts larger than 1 in. in diameter. The overall lengths of wrench given in the table are recommended for use with the sizes of bolts also shown in the table below.

A good rule for approximating the correct length of wrench is to multiply the bore of the nut, or the diameter of the bolt, by 15. The result obtained is the length of the wrench in inches. For example, a 1-in. bolt would require a 15-in. wrench and a 2-in. bolt would require a 30-in. wrench.

Length of Wrench for Different Sizes of Bolts

Size of Bolt, Inches	Length of Wrench, Inches	Size of Bolt, Inches	Length of Wrench, Inches
½	7¾	1¼	19
⅝	9⅞	1½	23
¾	11½	1¾	27
⅞	13¼	2	30½
1	15	2¼	34

Circuit Breakers for A. C. Motors

(*Continued from page 579*)

In one very important installation of this class, each three-wire lighting feeder is protected by a three-pole, three-coil breaker, equipped with shunt tripping coil. The compensators, of which there are two, intended to be operated either separately or in parallel, are each protected by a pair of double-pole, overload and no-voltage circuit breakers. One of these circuit breakers is connected in the positive lead and equalizer main of the compensator; the other breaker is similarly connected into the negative side of the compensator, and the two instruments are so interlocked that the opening of one causes the opening of the other, although they may be closed independently. Auxiliary circuit-closing devices are provided which bring into circuit the shunt tripping coils of the feeder circuit breakers when the compensator circuit breakers are opened. Thus should the compensator be out of service, the lighting feeders will be automatically disconnected.

Where overload circuit breakers are employed for the protection of compensators they should be equipped with direct-acting time-limit features. They then afford protection against short circuits and unduly sustained overloads, but being insensitive to slight overloads of momentary duration do not cause unnecessary service interruptions.

Maintenance and Operating Costs

(*Continued from page 570*)

The location of the various units which co-operate in the manufacture of roofing has an important bearing on the occasional production and handling of this commodity. Rag collecting depots and the felt mills are, accordingly, located where abundant water and labor are obtainable, at suitable shipping points near the sources of rag supply, particularly in the eastern central states. The price of rags varies considerably throughout the year; so large rag storage adjacent to felt mills is essential in the successful conduct of this business. It seems best to locate saturating, coating and shingle plants more with relation to the distributed market, at various good shipping and labor points throughout the country. Roofing felt can be shipped in rolls, protected against the absorption of moisture. Roofing asphalt can also be shipped readily in tank cars provided with coils for steam heating when unloading in cold weather.

The oil refinery is located in the main channels of transportation from Mexico and the Southwest to the market center in the central states, so as to distribute asphalt to the saturating and coating plants and at the same time be able to distribute competitively to other markets by-products which are not used in the roofing industry. Owing to fluctuations in the price of oil throughout the year, and to insure continuous operation, considerable storage capacity for crude at the refinery is essential. Storage for roofing asphalt is best provided at the saturating plants.

Owing to the differing and varying requirements of the markets supplied by individual roofing plants, and the economy of performing the granulating operation on as large a scale as possible, the slate granulating plants are best located at the quarries or mines. By this arrangement it is comparatively simple to carry the rock from the ground through the granulating plant into box cars and deliver it to protected bins at the coating plant without allowing it to become exposed to moisture.

The quantity of ground mica or talc used in the industry, for coating varieties of smooth surface roofing, is small and easily obtained.

Testing Wiring of Transformers

(*Continued from page 565*)

the secondaries of each transformer in one bank.

In paralleling three-phase transformers, it is necessary to observe the phase rotation of the primary and secondary as well as polarity, impedance, and voltage ratio.

Method of Testing Three-Phase Transformer Connections

To determine whether two three-phase transformers are properly connected for parallel operation, connect the high-tension sides of both transformers to the power supply after having connected the low-tension side of one to the low-tension bus as shown in Fig. 15. Then connect one low-tension lead of the second transformer to the bus. With a voltmeter measure the voltage across *M* and *N* and across *O* and *P*. If there is zero voltage across these pairs of leads the polarities of the two transformers are alike and the transformers may be paralleled. If the voltages across the two pairs of leads are double the rated secondary voltage then the polarity of one phase winding is reversed with respect to the other. The remedy is to reverse the polarity of one transformer by changing the internal connections.

If the voltage across one pair of leads is zero and is twice rated voltage across the other, the polarity of the transformers is correct, but the terminals are in different order. The remedy is to interchange *M* and *O* so that *M* and *P* will make one bus connection and *O* and *N* the other. The voltage should be measured across the new pairs of leads to be sure that it is zero before the connections are made.

If one voltmeter reads zero and the other reads 1.73 times the secondary voltage, we have a case of reversed polarity and transposition of terminals combined. The remedy in this case will be to change the internal connections of the transformer.

An example of transposition of leads on a three-phase transformer is shown in Figs. 16 and 17. The nameplate gave a connection diagram as shown in Fig. 16 and its vector diagram is shown below the connection diagram. The transformer was tested by using single-phase low voltage on the high-tension leads *A* and *B* (which excite the center winding of the transformer). The maximum secondary voltage observed was from *A'* to neutral, which proved that the *AB* winding and the *A'* low-tension winding were on the same leg of the core as shown in Fig. 17. The other two windings in Fig. 16 were checked similarly.

Thus it was found that the transformer secondary leads had been crossed inside the case so that the phase rotation of one transformer did not conform to the other one. It should be noted that the voltages of the low-tension *B'* windings in the two transformers are 120 deg. to each other. The same is true of the *C'* windings. If the secondaries were to be paralleled, a serious short circuit would occur.

Shelves and Racks in Storerooms

(*Continued from page 573*)

a small shelf, or ledge, of convenient height for working on; several of these are shown in accompanying illustrations. When units are assembled "double-face" or "back to back," one back may be made to serve both units.

Shelves may be turned into bins by adding "bin fronts" which are generally made in the same height as the vertical adjustment, 2 or 3 in., or in multiples of it. In addition, some provision is generally made on the front for attaching cards or other identifying means to show what is in the bin.

Where dust may injure the materials stored, or where it is desired to keep them under lock and key instead of in open storage, although the storeroom may be enclosed, either sliding or swinging doors may be attached to most kinds of shelving. How this is done is shown in some of the accompanying illustrations. In other cases where dust only is to be kept out, drawers or boxes are used in the storage space. These are usually made so that they fit rather closely but not too tightly at the top, so that they exclude most of the dust. These boxes may be made with several compartments and so used to store a number of different supplies which are kept in small quantities, thus adding to the total capacity of the storage space. For example, a 4-in.x6-in.x18-in. box may have several compartments, each holding a different stock part. For the smaller boxes these compartments are frequently made with wooden front and back and metal sides and bottom. This reduces the wood used to a minimum and, at the same time, gives the thin sides which are one of the big advantages of steel boxes over wooden boxes for shelf storage.

Open steel shelving differs from closed steel shelves in more than merely being without a back. In the closed type of steel shelving the back and side pieces help to support and strengthen the construction. In the open type of steel shelves, these are lacking and the shelves are attached directly to the steel framwork. This gives a construction with advantages both as to light and as to the proper selection from the pile and when placing material on the shelf. Open shelves are generally used for storing tools, punches, dies and similar material where it is of irregular shape and there is no particular reason for keeping one part or item separate from the others, as there is in the case of many manufactured or supply parts which may be similar to others.

In selecting either open or closed shelving, care must be taken to see that it is strong enough for the loads it is called upon to sustain. Also, it is always well to bear in mind that shelves should be made strong enough to sustain practically any loading which may be put upon them in the shop. Frequently shelves which are called upon originally to bear light loads may, under a change of conditions or product, be either moved or required to sustain a much heavier load. When there is a question as to whether the shelving will stand up under the new conditions the decision generally is to "try it out." Steel which has been "sprung" by overloading, however, does not have the power to withstand or carry the load which it did before. In this way, it is always well to consider future possibilities.

In planning for shelf storage, it is necessary to take into consideration the following factors: (1) The dimensions of the room to be devoted to storage; the height of the ceiling, location of pillars, posts or other obstructions, size of doors and windows and location of any permanent room fixtures. (2) The nature of the material to be stored; that is, whether it is light or heavy, bulky or compact, small units or large, whether it is loose or in packages. (3) Is

it necessary to make provision for card indexing the contents of each bin? (4) What load per square foot of shelf is to be carried? What is the permissible loading per square foot of floor space? (5) What size unit of shelf could be adopted as standard, or would a wide variety of sizes or spaces be necessary?

In considering any installation, it is well to bear in mind a few things concerning shelving. First, every type of equipment has its limitations. Steel has a definite strength according to its gage and bracings, and if it is overloaded far in excess of what it is supposed to carry, excessive and perhaps damaging strains may be set up in the steel work. If heavy loads are to be carried, it is usually possible to make narrower or reinforced shelves.

The manufacturer of the shelving gives complete directions for its erection. Incidentally, most of the better grades of shelving will go together easily if the directions for erection are followed. In some of the cheaper types more difficulty is involved in their erection. Outside of that, there are two points which need to be kept in mind. The first of these is that if the floor is not level care should be exercised to see that the partition or framework is blocked up so that the whole unit is sitting firmly on the floor without any twisting or causing other unusual strain. The unit could be strained much more severely by being erected on uneven flooring than it would ordinarily be through the weight of the material contained in it. The other point to remember is that all bolts should be made tight. Loose bolts will permit sections to bulge or give and throw unnecessary stresses into the steel work. Another unnecessary strain is often caused by men carelessly climbing up shelves midway between supports.

Ease in erecting and dismantling are always points to be considered. While a stock room is generally considered to be a permanent institution, conditions change so much in industrial plants that this is seldom true. When changes must be made the ease with which this can be done is important.

EDITOR'S NOTE: Acknowledgment is made to the following companies for assistance in furnishing information and photographs for this article: The Berger Mfg. Co., Canton, Ohio; Hadden Bin Label Co., Hadden Heights, N. J.; The E. F. Hauserman Co., Cleveland, Ohio; Lyon Metallic Mfg. Co., Aurora, Ill.; The Mills Co., Cleveland, Ohio; The Van Dorn Iron Works, Cleveland, Ohio.

Practical Books

For Your Personal Library

Every man who aspires to larger responsibilities should build up a professional library. Copies of these books may be obtained from the publishers mentioned.

Principles of Business Writing—By T. H. Bailey Whipple, literary critic. Westinghouse Electric & Mfg. Co. Published by Westinghouse Technical Night School Press, East Pittsburgh, Pa., 182 pages, price $2.

This book takes up three subjects which should be of interest to every technical or industrial man. These are: letter writing, report writing, and words and phrases often misused. As much of a man's success in the better jobs depends upon his ability to express himself and present his ideas in writing to those above him, a book of this type should be very valuable to industrial men, as well as to those who are engaged regularly in the preparation of business letters and reports and desire to become more proficient in this work.

* * * *

Arc Welding Handbook—By C. J. Holslag, chief engineer, Electric Arc Cutting and Welding Co. Published by McGraw-Hill Book Co., 370 Seventh Avenue, New York, N. Y. First edition, 243 pages, illustrated, $2.

This book, which is of handy, pocket size, was written to serve as a simple and practical manual of instruction in arc welding for both operators and supervisors, as well as a reference guide for all who are concerned in any way with the use of arc welding.

The preliminary preparation of the work and the methods employed in making all types of welds are described clearly and in sufficient detail to meet the needs of the beginner—while the experienced operator will find much that may be new to him. A list of questions has been appended to each chapter for the purpose of helping the student or reader obtain a more thorough grasp of the principles explained.

* * * *

Truscon Maintenance Data Book—Compiled and published by The Truscon Laboratories, Detroit, Michigan, 100 pages, illustrated. Price $3.

If you want to know how to waterproof the basement, daylight the interior of the factory, protect the roof against leakage, harden the concrete floors, clean windows of rust, enamel shower bathrooms, paint concrete, give steel an acid protective coating, or varnish or waterproof canvas, you will find full information with recommendations on how to take care of any of these conditions in this book. All information is compiled strictly from the maintenance point of view and is fully illustrated with maintenance charts, color charts and photographs.

In this book maintenance is classified under the following headings: Exterior, interior, floor, basement and roof. With this classification and the cross index practically everything in regard to any section of a building can be conveniently referred to. Another feature of special interest in this book is the eight pages of useful information, covering everything from weights and measures to mensuration formulas. Because of its completeness and the cost of producing it, the book is not issued for general free distribution.

* * * *

Management's Handbook — Edited by L. P. Alford, Editor of *Management and Administration*. Published by the Ronald Press Co., 20 Vesey St., New York, N. Y., 1,607 pages, 630 illustrations, 290 tables, flexible binding. Price $7.50.

In this first handbook on management subjects the editor was assisted by thirty-four others, each an authority in his subject. The information is well selected, inclusive and carefully arranged and a complete index makes it readily accessible. It should be very helpful to anyone holding a responsible position in industry or business.

There are thirty-two sections in the handbook as follows: Tables and statistics, mathematics, charts, management ratios, the industrial plant, plant layout, office management, forms, classification and symbols, purchasing and storeskeeping, tool storage and issue, production control, control of quality, material handling, operation study and rate-setting, wage payment and timekeeping, simplification and standardization, plant maintenance, conserving and salvaging materials, packing for shipment, traffic and shipping, economic principles, organization for ownership, organization for operation, budgetary control, cost accounting, cost and profit variation formulas, banking relations, insurance, market analysis, labor maintenance, information filing system.

* * * *

Electric Elevator Equipment for Modern Buildings—By Ronald Grierson, associate member of the Institution of Electrical Engineers and of the Institution of Mechanical Engineers. Published by D. Van Nostrand Company, 8 Warren Street, New York City, 173 pages, illustrated. Price $5.

The object of this work is to present to engineers, architects and others interested in the subject, a practical guide for the selection, installation, operation and maintenance of modern electric, passenger, freight and service elevators and escalators. A feature of this volume is the attention paid to the problems of selecting an elevator of the proper type and capacity.

One chapter is devoted entirely to specifications. An appendix gives a checking list which contains practically every possibility or condition which might come up in the installation.

Other sections of the appendix are devoted to elevator accidents, regulations relating to the installation, operation and maintenance, inspection form and test sheet. This volume is based on both English and American practice.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Electric Light and Reflector Cleaner Company, Appleton, Wis.—A folder describes a special device with which lamps and reflectors can be cleaned from the floor without removing them or using a ladder.

The Truscon Laboratories, Detroit, Mich.—The "Truscon Maintenance Map" presents in simple, easily understandable form a maintenance guide for buildings and equipment. It shows a cut-away view of the building, in colors, and points out by arrows and descriptive text the proper paint or protecting coat to use for floors, walls, machinery, pipe lines and other surfaces. In addition, a concise table gives a large amount of useful information regarding the quantities of these materials required.

The Texas Company, 17 Battery Place, New York, N. Y.—The October issue of "Lubrication," issued by this company is devoted to a discussion of lubrication in the paper industry. The information presented is also given in tabular form for quick reference.

Century Electric Company, St. Louis, Mo.—A folder entitled "Bearing and Oil Well Construction" gives a complete description and discussion of the advantages claimed for this equipment in Century polyphase motors.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—Publication S. P. 1666 entitled "Silent Sentinels" is a 72-page booklet on protective relays for alternating and direct-current systems. This contains the results of many years of experience in the manufacture and study of relays by the Westinghouse Company and over 140 illustrations, including schematic, vector and wiring diagrams to supplement the description of the theory and practice of relay operation.

Square D Company, Detroit, Mich.—Announcement is made of a new type of voltage tester which does not require the use of lamps. This will also indicate whether the current is alternating or direct and will indicate the voltage up to 600 volts. It is easy to carry and claimed to be simple to operate and to replace lamps in locating open circuits, blown fuses and motors running single phase.

Economy Fuse and Manufacturing Company, Greenview Avenue and Diversey Parkway, Chicago, Ill.—A folder describes the various ferrule and knife blade type fuses and the removable plug as well as giving prices.

General Electric Company, Schenectady, N. Y.—Circular 67,640.2, Class 15, describes the induction over-current time relay with circuit-closing contacts, controlling one circuit. These are made in different types for slightly different application.

The Van Dorn Electric Tool Company, Cleveland, Ohio—A 60-page booklet entitled "Higher Holeage" is more of a handbook on electric drills than is the ordinary catalog. This booklet is divided into the following twelve chapters: The history of holemaking; holemaking by electricity; electric drills—the machine guns of industry; higher holeage—lower cost; unusual uses of Van Dorn drills; holes in a hurry for shop repairs; buy your drills for "holeage"; operation and care of electric drills; electricity versus air for drilling purposes; tools recommended for various wood drilling operations; America's finest family of holemakers. The chapter on operation and care of electric drills not only gives directions for their proper use, but also calls attention to the most frequent misuses of this equipment. Special attention is given to a discussion of the proper sharpening of twist drills.

American Optical Company, Wellsworth Safety Division, 700 West Fortieth Street, New York, N. Y.—A new catalog entitled, "Industrial Head and Eye Protection," shows a wide variety of goggles for dust and chip protection as well as welding masks, helmets, and goggles for the various types of welding protection. A chart shows the protection afforded by different lenses against the ultra-violet and infra-red rays.

Electric Machinery Manufacturing Company, Minneapolis, Minn.—Bulletin 854 entitled, "Synchronous Motors for Compressors," discusses the suitability of a compressor for a synchronous motor application, the selection of the motor, fitting motor to the compressor, fly-wheel effect and details of a special engine type motor, which is designed for direct connection to compressors.

The Foxboro Company, Inc., Neponset Avenue, Foxboro, Mass.—A group of bulletins describe the recording gages, thermometers and other instruments made by this company. Considerable emphasis is placed on the improved helical tube movement for controlling the movement of the recording pen.

Gregory Electric Company, Sixteenth and Lincoln Streets, Chicago, Ill.—"The Monthly Bargain Sheet" lists, describes and prices the various new and "Gregory Rebuilt" electric motors, generators, switchboards, transformers, various starting equipment and other apparatus on hand for sale.

Moloney Electric Company, St. Louis, Mo.—This company is distributing monthly bulletins containing technical information on transformer data made up in page form suitable for clipping and inserting in looseleaf binders. The first of the series gave the method of connecting low voltage, single-phase distribution type transformers for different types of service. The second discusses the polarity of single-phase transformers, polarity—its meaning and marking, Moloney transformer data, and testing for polarity. The third of the series will contain a discussion of impedance of transformers and methods of measuring impedance.

Greene Equipment Corporation, Monadnock Building, Chicago, Ill.—A circular describes the new Leonard Morrow commutator tool which consists of a special bracket which is attached to the bearing and supports a turning tool for truing commutators of motors without removing the armature from the original bearing. Different size commutators may be trued by the use of large or small brackets on the same truing tool.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—A wall chart HC-233 entitled "Westinghouse Insulation Guide for Industrial Motors" shows in chart form the various Westinghouse insulating materials and insulating compounds for rotating and for stationary parts. This chart lists the various places where insulations are used and the different types of Westinghouse insulations adopted for each place.

Elgin National Watch Co.

(Continued from page 559)

Many of these steps are performed on special machines, some of which are shown in the accompanying illustrations. Some of the drills are so fine that they can hardly be seen. However, should one of these tools fail, the machine automatically stops and a signal flashes. The making of a balance wheel calls for a greater number of operations than are required by any other unit of the watch. For example, the rim alone is pierced with twenty-six threaded holes. These holes are made by a steel drill finer than a human hair. Over a million of these drills are required annually.

The mainspring and balance- or hair-spring are two important parts of the watch. The hairspring is made by drawing steel wire through a hole in a diamond. A pound of steel used for springs costs $5 or $6 and will make eight miles of hairspring wire worth $62,000.

The buildings at the Elgin factory are comparatively narrow and provided with a large window area to supply as much natural light as possible. This is supplemented by artificial illumination as care must be exercised to prevent eye-strain because much of the work of manufacture and assembly is performed under a magnifying glass.

Up from the "Stove Committee"

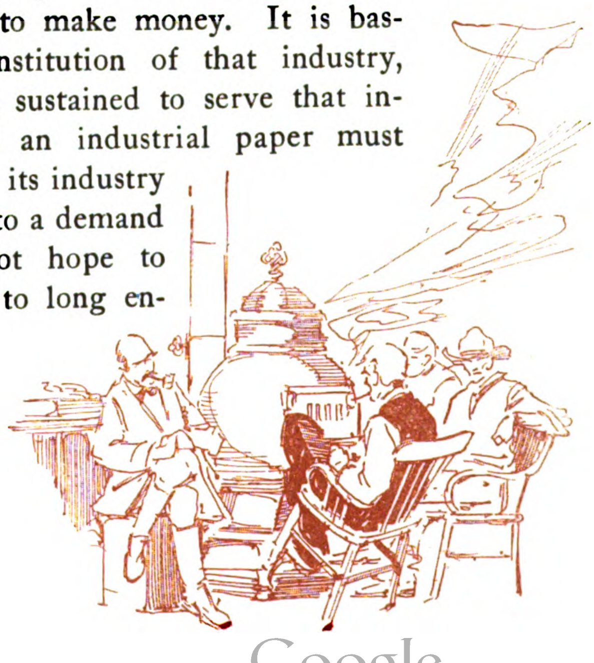
IN THE old days when communities were small it was very easy to get the news. The "stove committee" met each evening in the village store. The chief men gathered there and sat round the pot-bellied wood burner and the sawdust box and smoked and chewed tobacco. They gossiped, talked politics, argued on religion, compared experiences, heard the news and carried it home. The "stove committee" of the village store has been a very fundamental institution in the development of American social and civic life.

But as each community has grown large there has always come a time when all the thinking men of the town could no longer meet together around a stove. There were too many of them. Some new method of expression had begun to be vitally needed to tell the news and what men thought about it—and they seized upon the art of printing. So it has been in town after town over the world—first a "stove committee," then a newspaper. And the press in every case has sprung from the community because the community needed a vehicle for expression.

The Industrial Community

The process has been the same in industry. For industry brought a new kind of a community into the world, a community of men scattered across wide areas but nevertheless engaged in a common work and common thinking. These men, located in very many towns, could never, of course, come together in a village store. But they had common interests and common problems, and they also felt the need for a medium of expression, a way to learn the news and opinions of the leading thinkers of their industry. And so came the industrial press, the business press, to satisfy that need.

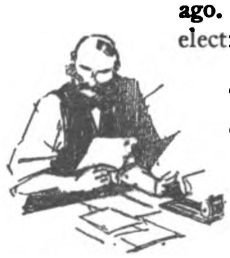
For the press of any industry is not just a private enterprise started because some man wants to make money. It is basically an institution of that industry, created and sustained to serve that industry, and an industrial paper must spring from its industry in response to a demand or it cannot hope to prosper or to long endure.



The Electrical Industry a good Example

There could be no better illustration of all this than is found in the electrical industry. It is particularly interesting because the whole development has come within the space of fifty years. And we have seen the "stove committee" of that small group of early pioneers—Edison, Sprague, Brush, Bell and their few associates and followers—evolve into a great industrial community numbering today fully a million men and women. As the industry has grown, the need has grown for service from the institution of the press, and to meet that need the electrical press has sprung from that community—first a single paper, then other papers, as groups of electrical men began to specialize. The whole process is vividly pictured in the story of the McGraw-Hill electrical publications, which at the start numbered only one and today have increased to six papers, each serving some well-defined community of interest among electrical men.

The First Electrical Paper

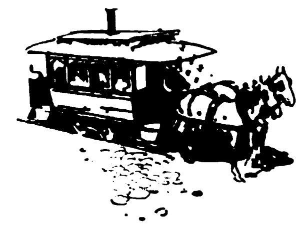


THE first electrical paper began publication in 1874, a few months less than fifty years ago. It was called *"The Operator,"* for the electrical industry then embraced just the telegraph. But soon things began to happen. The incandescent lamp, the motor, the central station came and the vision of the electrical industry began to dawn. This pioneer paper changed its name to the *Electrical World,* and from that day to this, through all these years, it has continued, expanded and developed with the industry it serves.

No better record of the evolution of the electrical industry can be found than in the back files of the *Electrical World.* Through the eras of research, invention and engineering into the present era of economics and market development it has followed the trend of ideas and events in the world of electricity. It has been and it is today the executive and engineering paper of the industry, the newspaper of the electrical man, the vehicle that brings him the ideas and opinions of others, the mirror of his progress, his mouthpiece and his guide.

A Paper for the Street Railway

BUT it was not long before small growing groups of electrical men began to separate themselves and form new interests. Sometimes such a group would come to need a paper of its own devoted to its special problems and its own news in detail. So it was when the street railways of the country began to abandon the horse and cable and adopt electric power. This radical change in the methods of local passenger transportation brought many new and complex problems demanding the freest interchange of experience and opinion. The old *Street Railway Journal,* founded as a street-car paper in 1884, was changed to the *Electric Railway Journal* and from that time on has given its entire attention to the service of this branch of the electrical industry.



A Paper for the Merchant

AND then another situation arose. Retail merchandising had grown to be so great an interest and activity among electrical men that a strong paper to serve that field began to be demanded. And so the McGraw-Hill Company, having for years carried the responsibility for maintaining the institution of the press on an adequate basis in the electrical industry, purchased *Electrical Merchandise,* a small paper dedicated to a big idea, and built it up into a strong guiding paper renamed *Electrical Merchandising.*

But it was not just the creation of a publisher. It was the expression, the instrument of a new virile, specialized community of electrical men that needed a paper of its own. *Electrical Merchandising* has crystallized a new trend in the industry and rendered a great service to the appliance department of the central station, to the electrical contractor and dealer and to the

manufacturer and distributor of electrical merchandise, by pioneering in this fallow field, promoting this new business, providing a source of merchandising ideas, experience and inspiration and also a market place vitally needed.

A Paper for a Locality

THAT made three electrical papers in the group. Meanwhile, out on the Pacific Coast electrical men had felt the want of a paper to serve that distant section, to publish local news and discuss their special problems. They started a little paper called the *Journal of Water, Gas and Electricity*. One day the leaders of the electrical community on the Coast appealed to the McGraw-Hill Company to buy their journal and, by putting its stronger organization behind it, make the paper serve them more adequately. This time the demand for a paper sprang from the needs of a locality. The renamed *Journal of Electricity*, devoted entirely to the interests of the Far West, has been developed to satisfy that need.

A Paper for the Industrial Electrical Man

TWO years ago came the fifth paper, the culmination of a long and steady pressure for still another specialization in the electrical press. For a long time the large industrial works of the country had been complaining that they had insufficient recognition in the electrical press, no adequate place in which to describe and discuss the operation and maintenance of electrical and associated mechanical equipment. As a group, these specialized electrical men had become so numerous and so important that they were entitled to consideration from the electrical press. So the old *Electrical Review* was purchased and turned into the *Industrial Engineer*. Again there arose an insistent demand, this time from a community of industrial men, and an old paper was made over for them.

A Paper to meet a Trend

THE youngest child in the electrical press is *Electrical Retailing*, and its reason for existence is particularly interesting. The number of non-electrical stores that sell electrical appliances is steadily increasing. Those merchants who have grown so interested in electrical appliances are fast becoming a factor in the electrical market, but they are not electrical men and, thinking principally of the processes of merchandising, have bought and sold for price with little appreciation of the vital importance of quality and the dependability of these devices in service.

They are not yet interested in the electrical industry. So it became exceedingly important that a paper be made for these non-electrical retailers and for many small electrical dealers who, because they as yet lack broad interest in the electrical industry, do not read *Electrical Merchandising*. The press was called upon to help, and so this little paper *Electrical Retailing* was purchased and is being built into a strong influence to meet this specific need.

THOUGH not an electrical paper, with this group should also be mentioned *Power*. This publication has for years devoted space each week to the practical consideration of such electrical subjects as are encountered in the operation of industrial and private plants and has endeavored to serve especially those who by education and experience have come up through the steam end of the business.

SO, STARTING with a single pioneer paper, the *Electrical World*, there have developed these other papers, and we see the McGraw-Hill electrical group today numbering six publications. They reach regularly a total of 82,500 men and women of the electrical industry (not including *Electric Railway Journal* or *Power*) and are read and used by probably twice that number.

Electrical World—the Master Paper

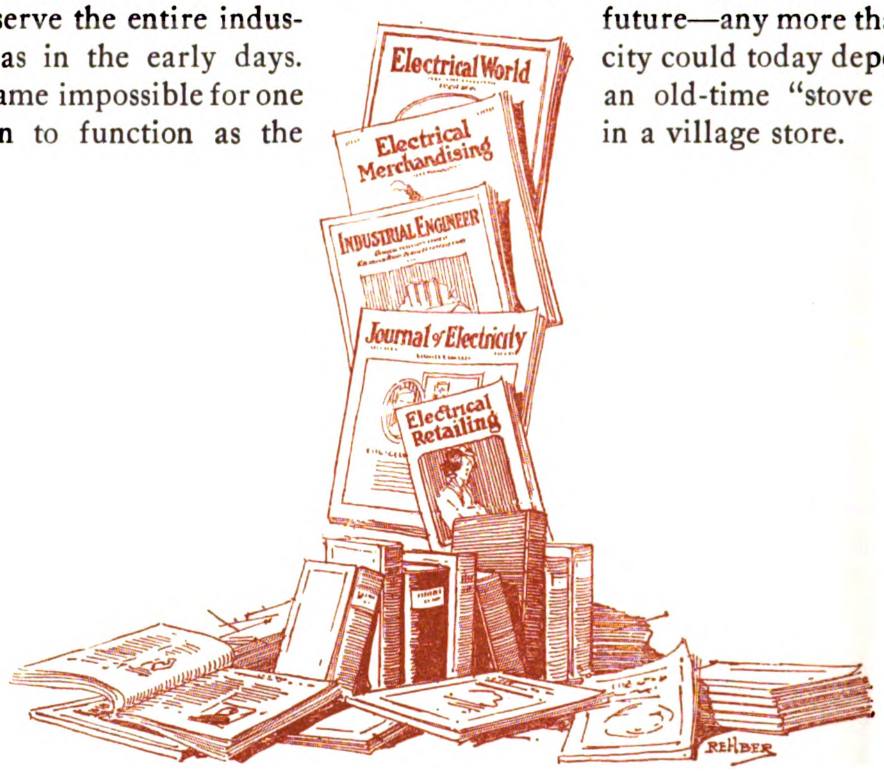
The *Electrical World* is the "master paper," the engineering and executive paper of the industry, the only weekly newspaper for electrical men—written alike for the central-station man, the electrical engineer, the manufacturer, the jobber and the large contractor. It

reflects broadly the progress of the industry, interpreting the ever-changing prospect, recording experience, carrying the thinking of important men out to their fellows, providing a forum where each branch of the industry may discuss its problems in the presence of the other groups. *Electrical Merchandising, Industrial Engineer, Electrical Retailing, Journal of Electricity* and *Electric Railway Journal* all are devoting themselves to the service of separate specialized communities of electrical men who as groups have peculiar problems that require a paper of their own.

Changing Conditions
the compelling Force

If the electrical industry had not grown and gradually divided itself into these different classes of electrical men, the *Electrical World* could have continued to serve the entire industry itself as in the early days. But it became impossible for one publication to function as the "master paper" of the electrical industry and also attempt to give detailed attention to special interests and spread itself over the entire fast-expanding field. Therefore, to provide a complete coverage and an adequate press service to these new groups of electrical men as they began to form themselves into clean-cut communities, the new papers have been established at the call of the industry.

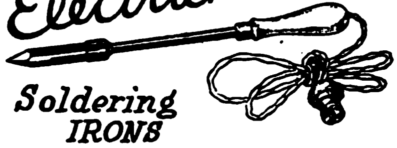
The industrial press belongs to the industries it serves. The electrical press is an institution of the electrical industry, established and supported by the industry for the dissemination of information to electrical men. Without the knowledge that comes to electrical men through the electrical press—through these McGraw-Hill electrical papers—the electrical industry could not have grown to its present greatness. Unless this electrical press continues to serve electrical men in accordance with their changing needs, the industry cannot hope to realize its great future—any more than a modern city could today depend upon an an old-time "stove committee" in a village store.



MAINTENANCE SERVICE, REPAIR PARTS, TOOLS AND SUPPLIES

In the maintenance departments of every industrial works and in every commercial electrical repair shop the range of the work that can be done and the dollar-savings that are possible depend on:
(1) The ability and experience of the maintenance man.
(2) Adequate hand and bench tools and shop equipment.
(3) A well-balanced stock of spare units, parts, wiring supplies and raw material used in repair work.
Here then is a directory to the needs of the maintenance man under items (2) and (3) that he can use when he must have things in a hurry on an emergency job and when ordering for stock to meet his regular maintenance requirements.

Electrahot



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Here is an all-round electric soldering iron for a thousand and one industrial uses. It operates from an ordinary lighting circuit. Includes 6 ft. cord and 2-piece plug. Also made with ⅜" point for fine work.

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HARD MAPLE WOOD ARMATURE WEDGES

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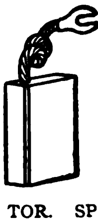

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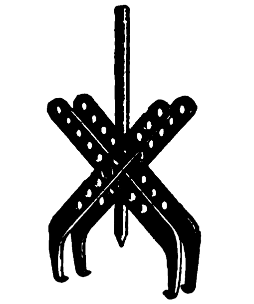

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The "Little Giant" and the "Big Buster" cover a range of work which is not approached by any other combination of pulling tools on the market. These tools cannot spread, turn or slip off the work; no arm locks required.

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A principle quickly understood and appreciated by mechanics who have had experience with ordinary pullers.
"Little Giant" and "Big Buster" will easily and quickly pull commutators, wheels, pulleys, gears, pinions, bearings or anything with a tight fit or that is hard to get at with ordinary tools.
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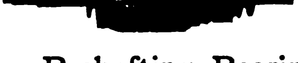

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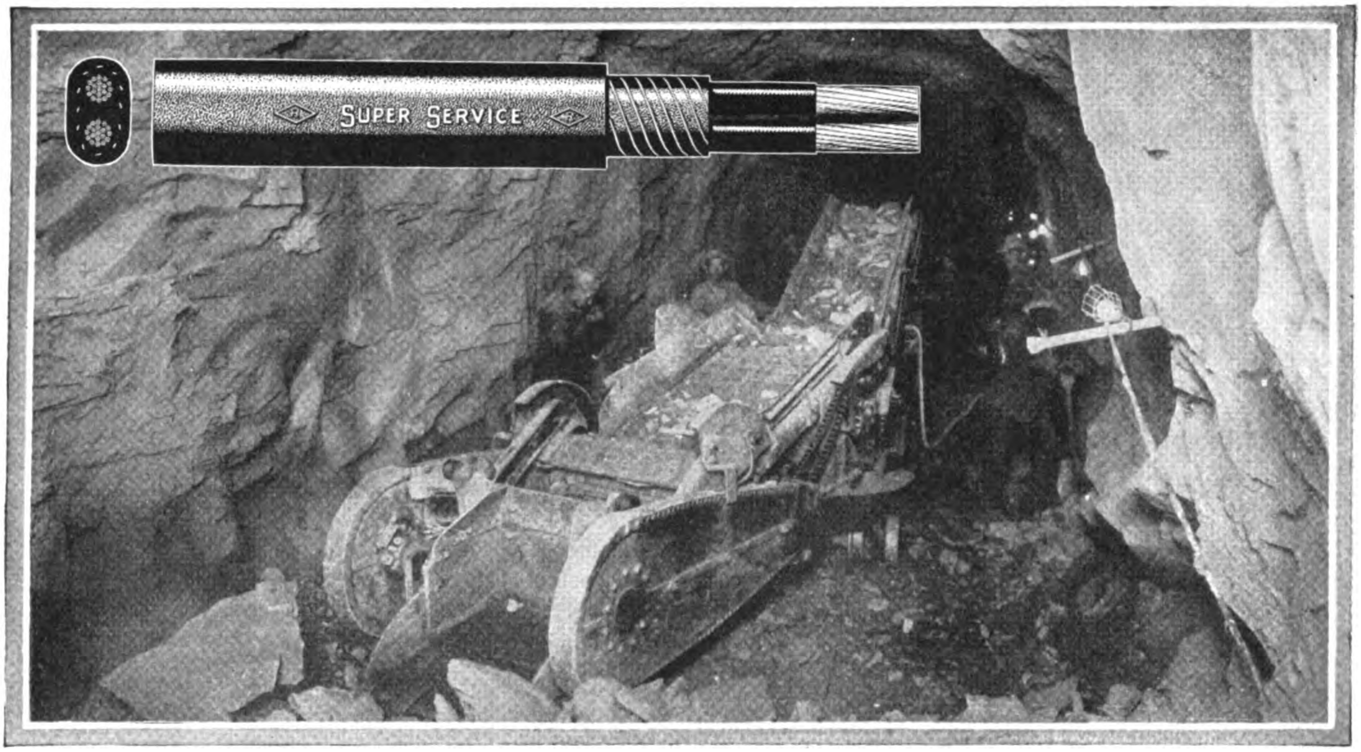

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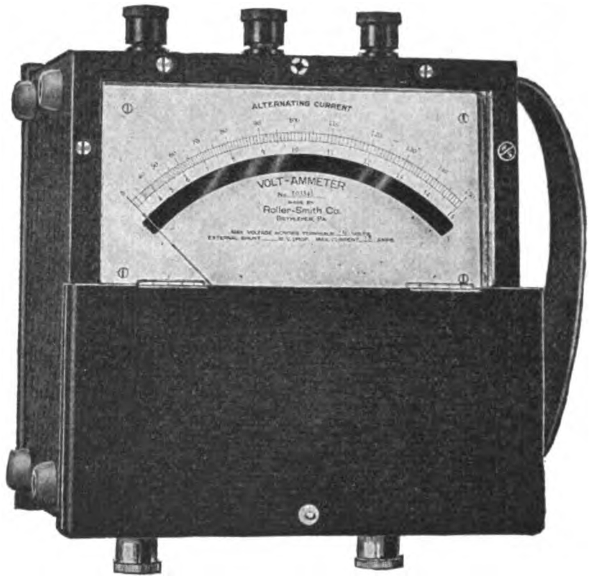

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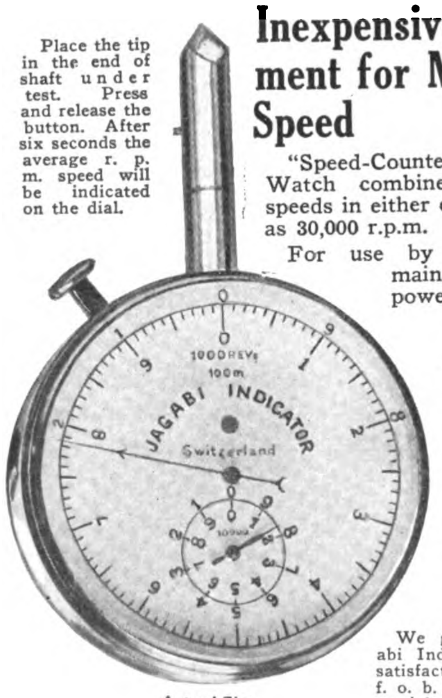

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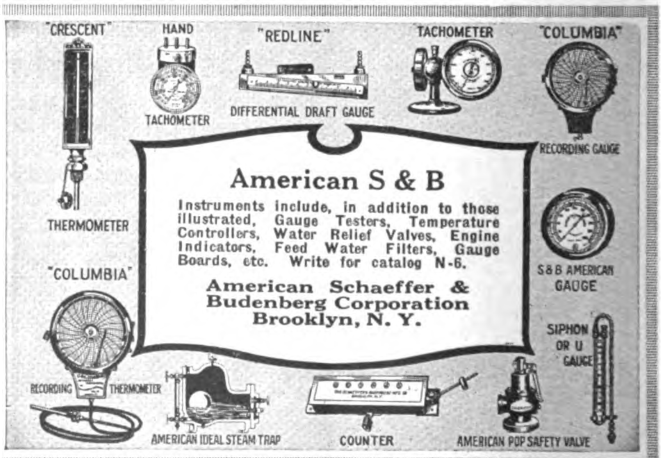

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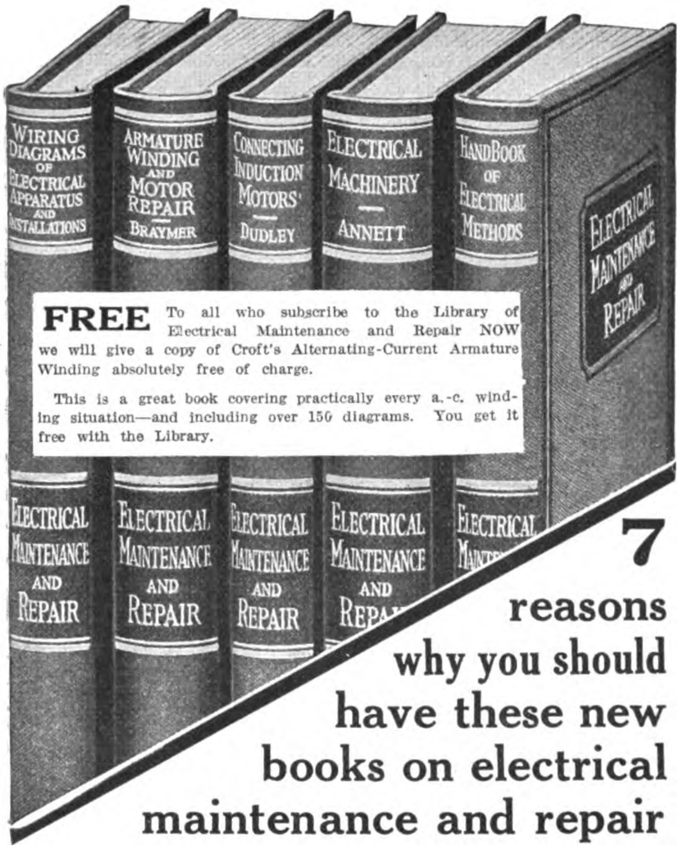

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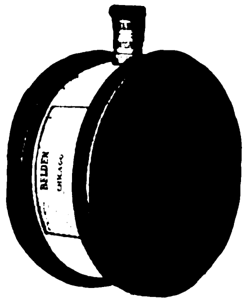

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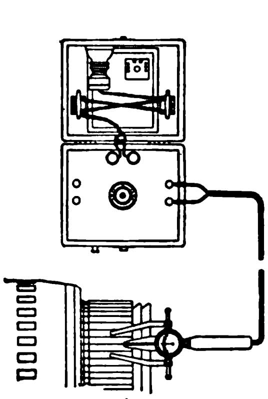

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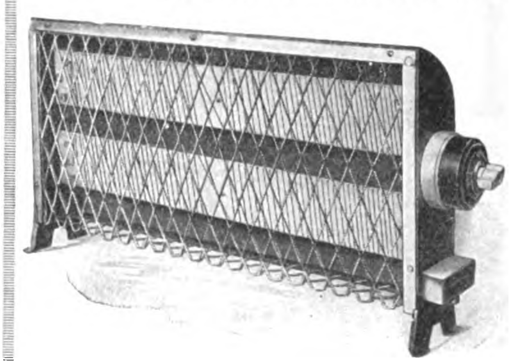

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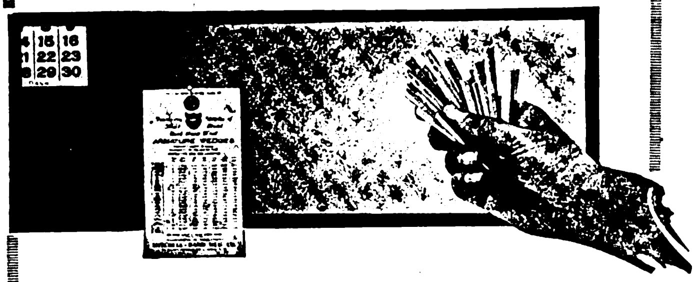

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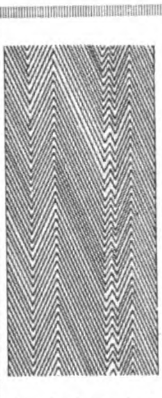

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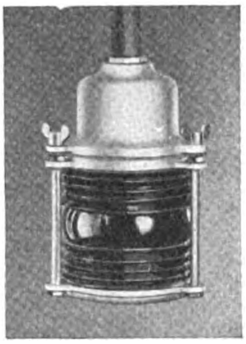
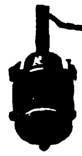
The "Eagle Eye" Signal Lantern





Six and a quarter inches high, this fellow, and less than two and a half pounds heavy. In lanterns, light weight and short life are generally synonymous, but not so with "Eagle Eye." Cast aluminum will stand weather, rough handling or acid atmospheres for many a day after less sturdy lanterns have passed on. This is a signal for countless warning jobs now being done ineffectively or not at all, and it will do them as they should be done—thoroughly and economically.

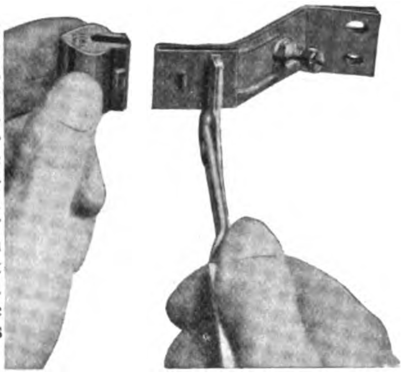
Write for complete details on "Eagle Eye," the boy who, with one bulb, sends a colored light all 'round him and a white light straight down.

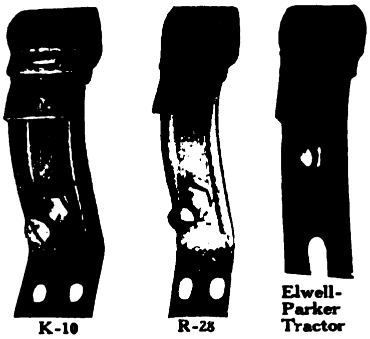
THE NICHOLS-LINTERN CO.

7960 Lorain Ave. Cleveland, Ohio

Represented in Canada by Railway & Power Engineering Corp. Toronto, Ontario

This cut shows method of reversing or renewing tips. We furnish the tools. Each tip will outwear two ordinary fingers on one side; then it is reversed, giving equal wear on the other side. When both sides are worn out a new tip is snapped on the finger while the finger remains on the controller.





K-10 R-28 Elwell-Parker Tractor

With Trigger-lock Fingers on your controllers you renew only the tips and Save Money.

Trigger-lock fingers are made for all drum controllers, starters, cars, trucks, tractors, compensators, etc.

Our illustrated catalog shows the line. Write for a copy.

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814 Bath Ave. NIAGARA FALLS, N. Y.

232 Westmount Drive TORONTO, CANADA

See These in operation at the Power Show!

ILLUSTRATED are four subjects taken from the more important products of Cory. The Cory-Recony Standardized Unit System for the remote closing of inaccessible gate valves—the Robinson Interlock to protect men from opening disconnecting switches under load—the Cory Central Station Annunciator that warns the eye and the ear of trouble in any part of the plant and the Cory Visible Signal Systems for the instantaneous transmission of messages between important points in Industrial Plants.

Industrial Engineers are invited to visit the Cory Booth and watch these Systems in operation. A true perspective of Cory Service in the saving of life, equipment and time.

CHAS. CORY & SON Inc.

The World's Largest Manufacturer of Signaling, Communicating and Lighting Equipment

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CORY SAFETY SERVICE TRADE MARK EST. 1840

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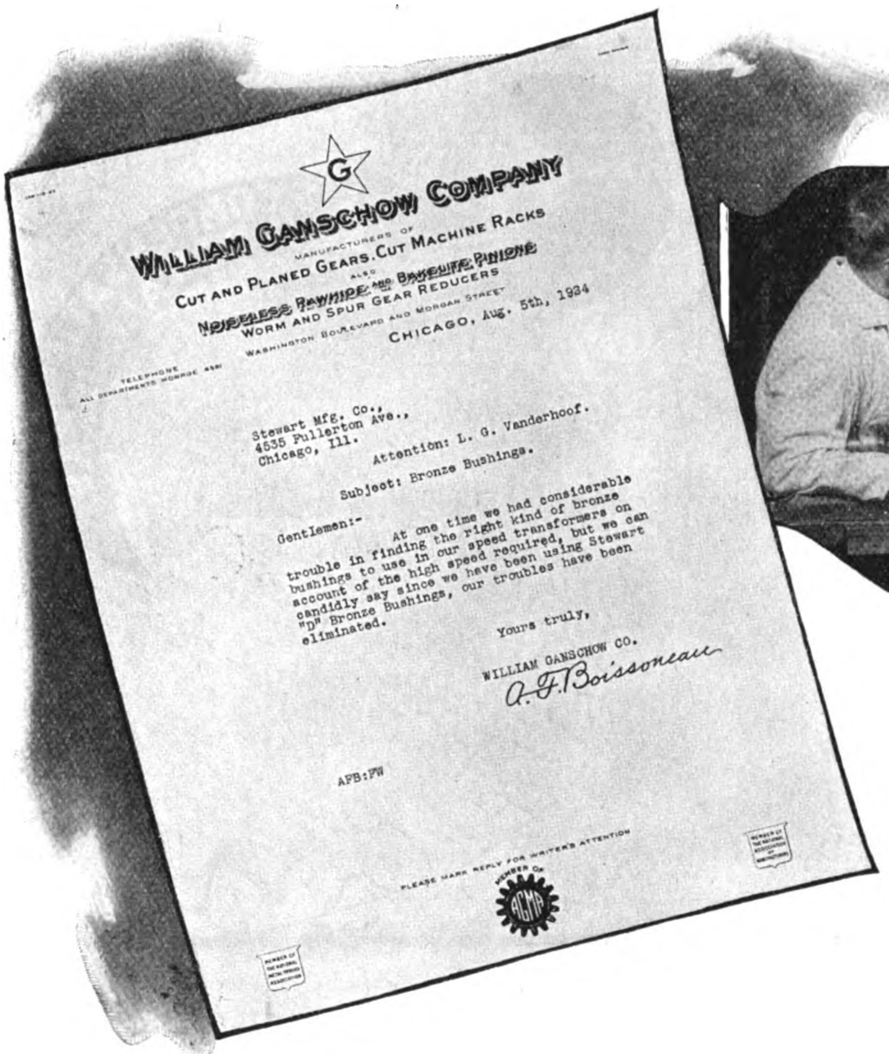

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MANUFACTURERS OF
CUT AND PLANED GEARS, CUT MACHINE RACKS
ALSO
NOISELESS RAWHIDE AND BAKELITE PINIONS
WORM AND SPUR GEAR REDUCERS
WASHINGTON BOULEVARD AND MORGAN STREET
CHICAGO, Aug. 5th, 1924

Stewart Mfg. Co.,
4535 Fullerton Ave.,
Chicago, Ill.

Attention: L. G. Vanderhoof.

Subject: Bronze Bushings.

Gentlemen:-

At one time we had considerable trouble in finding the right kind of bronze bushings to use in our speed transformers on account of the high speed required, but we can candidly say since we have been using Stewart "D" Bronze Bushings, our troubles have been eliminated.

Yours truly,

WILLIAM GANSCHOW CO.

A. F. Boissoneau

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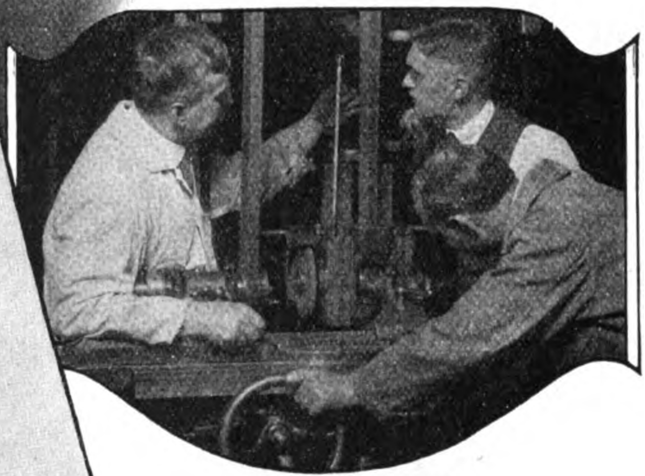

Stewart Brons is made in 258 stock sizes, finished all over, and in four degrees of Brinell hardness for all bearing conditions. Our standard Grade "D" Metal is perfect for average requirements. All solid and cored bars in money-saving 13-inch lengths.

Remarkable Evidence of the Superiority of Stewart Brons

Here's bearing quality, the like of which was never known until Stewart Brons proved that the secret of the perfect amalgamation of copper and lead was discovered.

Stewart Brons provided remarkable bearing quality through an unusually low coefficient of friction. Its melting point is 1700° F.; remember that ordinary babbitt melts at 400° F. At 600° F. Stewart Brons sweats a little lead, lubricating itself should lubrication fail. It will not burn out or score a shaft up to 1000° F.

What bearing trouble do **you** want to eliminate? Send your blue prints. Our Engineering Department will give you the information you need.

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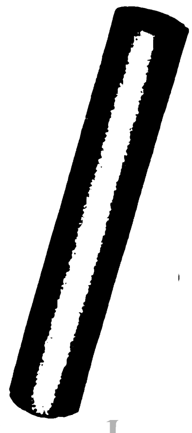

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The Perfect Metal for Bearings

Smooth Transmission at Uniform Velocity

At last! A smoother running, longer life Chain Drive, all due to that distinctively different and exclusively ***Ramsey*** feature —the ***Compensating Joint.***

Let us send you our highly interesting Text Book on Power Transmission, telling in a clear and convincing manner why the Ramsey Silent Chain Drive excels in the Power Transmission Field over other forms of drives—chain, leather, etc. It's free.

What's your name? Address?

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(*PATENTED*)

Main Office: 1047 Broadway, Albany, N. Y.

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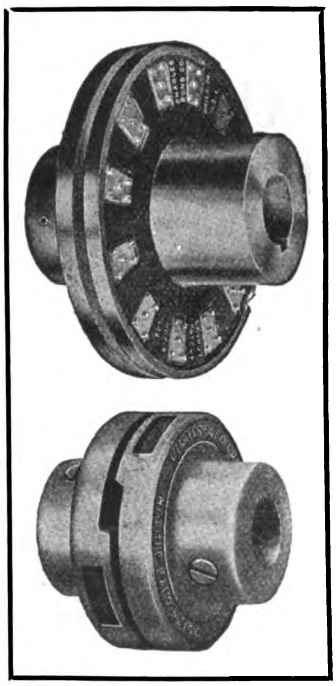

FLEXIBLE INSULATED COUPLINGS
(PATENTED)

that give you every advantage plus real service.

The GRUNDY

Here's a smoothly operating unit that will transmit more horsepower and give longer service than you have been accustomed to receiving. In addition to its efficiency, this coupling has no projections to cause damage.

The MATHER

A little cross-shaped leather insert gives this coupling great flexibility. Has few parts and thus is free from ordinary coupling defects. It's a most desirable coupling for use in connection with small motors and light loads.

Ask for Booklet "F."

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617-619 Arch Street **Philadelphia**

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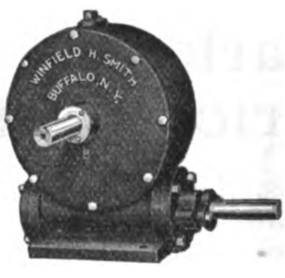

Why not connect direct to your motor? Eliminate cumbersome chains and countershafts.

Standard units carried in stock.

Reductions as large as 96 to 1.

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ELWELL-PARKER 6000 POUND ELECTRIC LIFT TRUCK

Will pick up and deliver more materials day after day at less cost than any similar truck.

Request details as to this new Special, illustrated in Bulletin A535

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CLEVELAND

Get *ALL* the power you pay for

Most shops are finding that the drive layout delivering the most power at the lowest cost per unit produced per year is the group drive using leather belts.

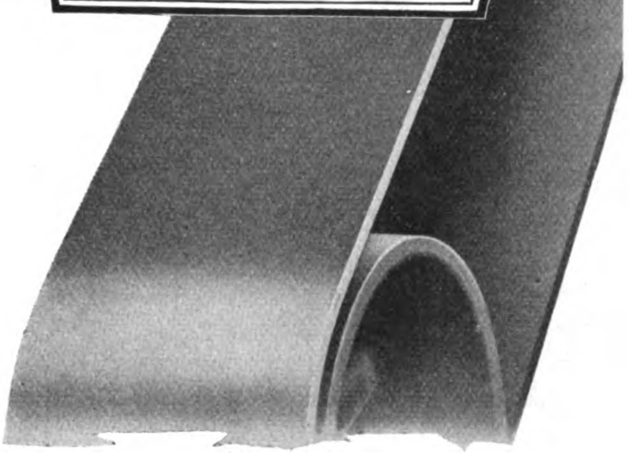
Leather belts transmit more power with less slippage and less bearing friction than any substitute. They have a longer life and a higher salvage value than substitutes.
From actual shop experience, the group drive with leather belts averages 1/6 as much time lost through breakdowns as the individual drive.

Read this:

Robert W. Drake, electrical engineer of the McCormick International Harvester Plant, has written three articles which have been reprinted in pamphlet form "When to Use Group and Individual Drives." He knows drives and belts—he has used nearly every kind of tool—HIS PAMPHLET IS PRACTICAL.

Use the coupon today;
it has put money in other pockets—get yours.

LEATHER BELTING EXCHANGE
Philadelphia, Pa.



Nothing takes the place of
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Address LEATHER BELTING EXCHANGE,
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Please send me a free copy of "When to Use Group and Individual Drives" by Robert W. Drake.

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Says:
"When ye put a joint together with

Burnley Soldering Paste

Write For a Free Sample

ye'll haf to git a team o' horses to pull it apart. They's many a paste I have used but the only one ye kin bank on to stick is ole Burnley. If you ain't tried it yit, write fer a sample to

The Burnley Battery & Mfg. Co.
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The Searchlight Section of This Paper—

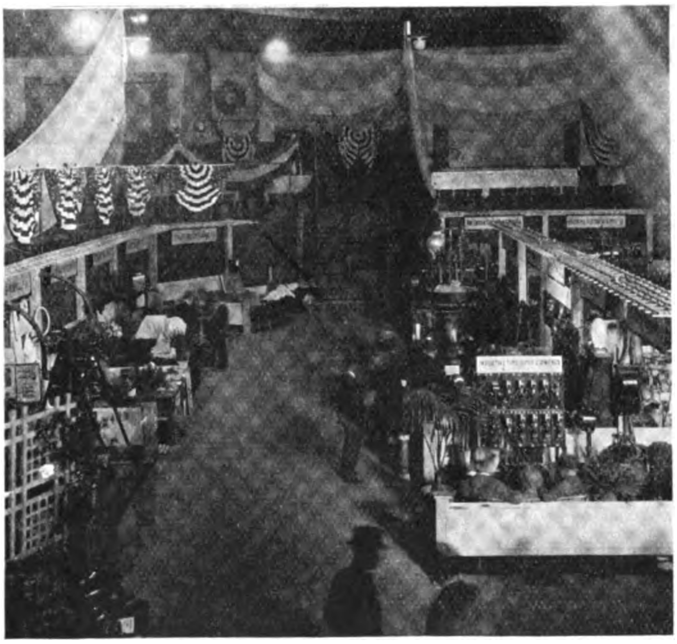
is devoted exclusively to the advertising of idle used and surplus new equipment, and all other business "Opportunities" identified with the field covered by this paper.

Buyers and others consult "Searchlight" ads for what they want.

You can reach them quickly and at small cost through an advertisement in the Searchlight Section of Industrial Engineer.

How would you like to spend an evening at an exhibit like this?

YES you would if you had the time, and perhaps the money, to visit such an exhibit and go through it from one end to the other. Of course there would be many items that you would find no immediate use for in solving your particular problems, but there will always be something of value, something to make the trip worth while.



ON the other hand, in February this year there will be an exhibit (on paper) of mechanical and electrical equipment especially and entirely adapted to the newer developments in industrial conditions, every item of which will concern you directly or indirectly. An exhibition without frills, without wasted effort, without lost motion or time. The February issue of Industrial Engineer will be, in effect, a convention of operating men from all parts of the country. The stories and articles to appear in this number, have been collected by editors traveling many thousands of miles and attending the largest conventions of the past year.

A national survey of industrial plant changes that tend to improve operating conditions will appear in the February issue of

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

McGraw-Hill Company, Inc.
Old Colony Building, Chicago, Ill.

Advertising forms close January 20

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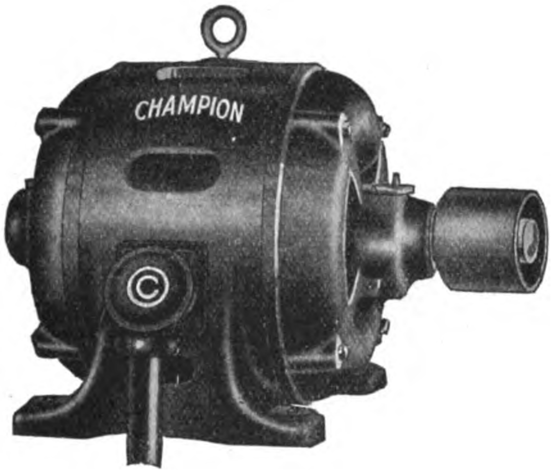
High Efficiency—Constant Service—Cool Running



Large Ventilating Areas Increase Overload Capacity and Life of Insulation — Prolong Life of Motor.

Single Phase 1/4 to 5 H.P.
2 and 3 Phase 1/4 to 20 H.P.
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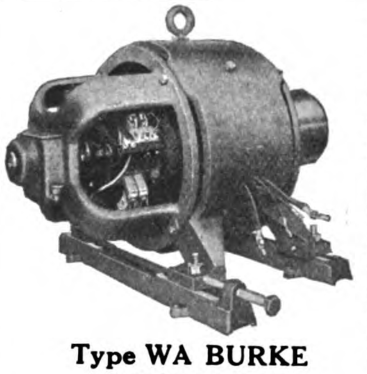
All Champion Motors are 40° C.

Write Us For Particulars and Prices.

Champion Electric Company, 3711-3741 Forest Park Blvd. ST. LOUIS, MO.

"Burke for Work"

Serving Industrial Requirements Correctly



Burke Motors have firmly established their great practicability in the minds of those who use them. That is why, when additional motor equipment is bought, the practical industrial man who knows Burke Motors specifies them. You will be repaid in real motor service later on if you investigate Burke Motors now.

Type WA BURKE
Direct Current Motor

Bulletins on Request

We also manufacture Alternators, Generators, Motor Generator Sets, Arc Welding Equipment and Transformers.

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Sales Offices: Buffalo, Chicago, Cleveland, Detroit, Erie, New York, Philadelphia, Pittsburgh. **Sales Agencies:** Underwood Electric Co., Cincinnati; W. T. Osborn, Kansas City; Coast Equipment Co., San Francisco, Cal.

Sturtevant Electric Motors

Direct and Alternating Current
Single and Polyphase
Generators and Generating Sets

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AN INVESTMENT IN GOOD SERVICE!

Phoenix Motors have grown in favor because they have produced results.

SERVICE TO THE USER
Minimum charge for maintenance and repairs and long life record.

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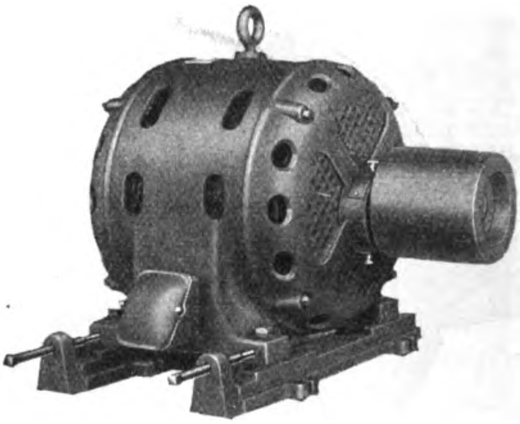

The 30 H. P. Motor

Century

Squirrel Cage Induction
POLYPHASE MOTOR

bearings are built of the best grade cast phosphor bronze and are of a size to give years of uninterrupted service. To further insure a long life to the bearings, the bearing housings and oil wells are made as near dust proof as it is possible to build.

Temperature rise not more than 40° C

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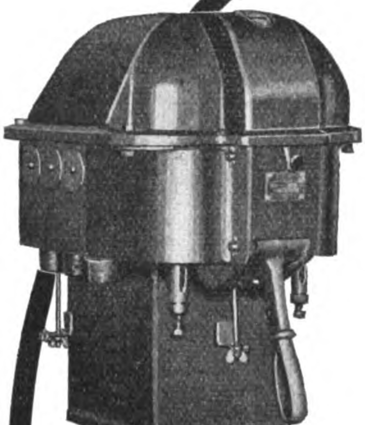
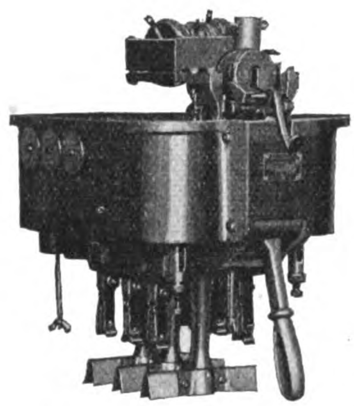
An inexpensive circuit breaker furnishing protection against overloads, short circuits and voltage failures on circuits of 2500 volts or less.

It is drip proof and dust proof. It mounts right on the wall, no switchboard panel being required. It is ideal for industrial plants.

It furnishes complete control and protection for motor circuits.



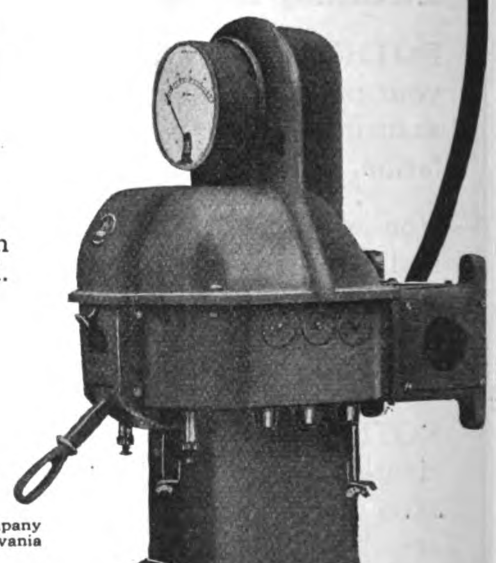
An F-10 Oil Breaker, 200 ampere, 2500 volt, 3-pole, Single-throw equipped with full automatic series current and trip overload coils, inverse time limit, under voltage attachments and voltage transformer.



F-10 Oil Breaker, with cover and tank removed.

Descriptive Leaflet 3400 gives all particulars.

Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania
Sales Offices in All Principal Cities of the United States and Foreign Countries



F-10 Oil Breaker, with Ammeter to indicate load conditions.

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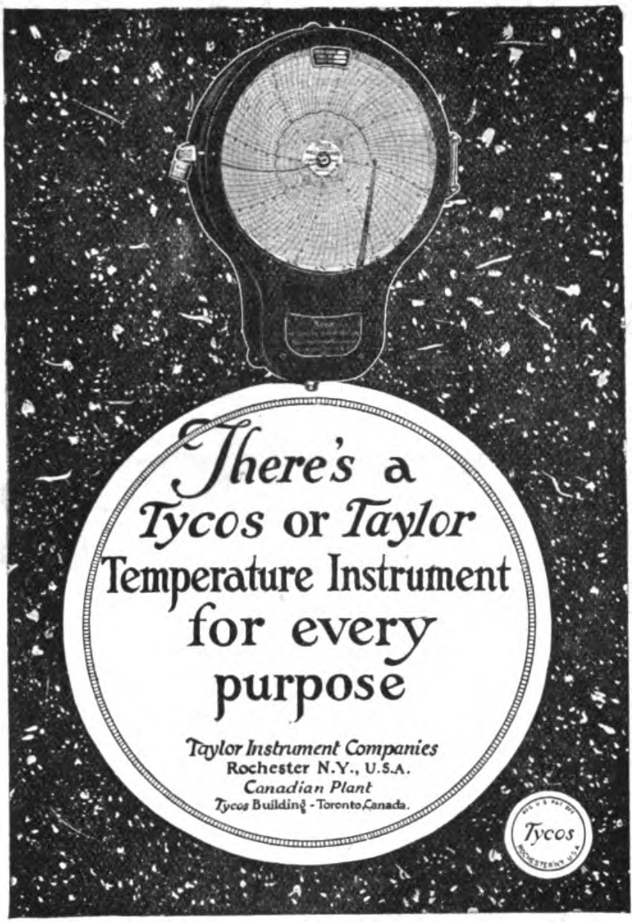

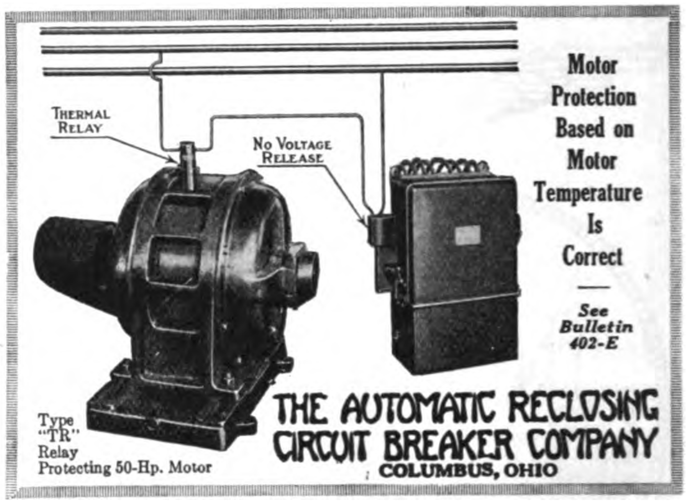

Take a tip from the calendar

The calendar "starts" with the first of the year. Your subscription to Industrial Engineer ought to start at the same time.

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I. E.

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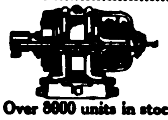

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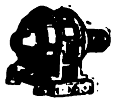

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Two 200 H. P. New 235 R. P. M. Westinghouse Electric Motors at fraction of original cost.

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in this paper reach the latter.

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"Think* SEARCHLIGHT *First"

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2304 Matthews Avenue Kansas City, Missouri

WHAT AND WHERE TO BUY

Equipment, Apparatus and Supplies Advertised in this Issue with Names of Manufacturers and Distributors

Prospective purchasers in the electrical-mechanical market are invited to apprise us of their needs, assuming, of course, that the articles sought are not listed here

INDUSTRIAL ENGINEER, OLD COLONY BLDG., CHICAGO

Arc Welding Sets
Allan Mfg. & Welding Co.

Air Cleaners
Midwest Air Filters, Inc.

Air Compressor Filters
Midwest Air Filters, Inc.

Air Compressors
Allis-Chalmers Mfg. Co.
General Electric Co.

Air Filters
Midwest Air Filters, Inc.

Armature Baking Ovens
Despatch Mfg. Co.

Armature Coil Spreaders
Mutual Foundry & Machine Co.

Armature Coil Winders
Mutual Foundry & Machine Co.

Armature Repair Machinery
Armature Coil Equipment Co.
Electric Service Supplies Co.
Mutual Foundry & Machine Co.

Armature Rewinding
Cleveland Arm. Wks.

Armature Wedges
Crafts Elec. Co., Jas. P.

Balls, Brass, Bronze and Steel
Skayef Ball Bearing Co.

Baking Ovens
Despatch Mfg. Co.

Battery Charging Apparatus
General Electric Co.
Hertner Electric Co.
Westinghouse Elec. & Mfg. Co.

Bearings
Ball
Skayef Ball Bearing Co.
Torrington Co., The
Roller
Bond Co., Chas.
Dodge Mfg. Corp.
Hyatt Roller Bearing Co.

Bearing Metal
General Electric Co.
Stewart Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Bells, Electric
Schwarze Electric Co.
Westinghouse Elec. & Mfg. Co.

Belts, Conveyor
Link-Belt Co.
Schieren Co., Chas. A.

Belt Fasteners
Flexible Steel Lacing Co.

Belt Drives
Smidth & Co., F. L.

Belt Lacings, Hinge
Flexible Steel Lacing Co.

Belts, Transmission
Bond Co., Chas.
Chicago Belting Co.
Link-Belt Co.
Schieren Co., Chas. A.

Blow Torches
Allen Co., L. B.
McGill Mfg. Co.

Blowers
Armature
Clements Mfg. Co.
Electric Blower Co.
Electric Portable
Clements Mfg. Co.
Electric Blower Co.
Green Equipment Corp.
Martindale Electric Co.

Bolts, Nuts and Screws
Sturtevant Co., B. F.

Books, Technical
Audel & Co., Theo.
McGraw-Hill Book Co., Inc.
Sweet's Catalog

Boosters
Allis-Chalmers Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Boxes
Conduit
Appleton Electric Co.
Hubbell, Inc., Harvey
McGill Mfg. Co.
Fuse
General Electric Co.
Junction and Outlet
Appleton Electric Co.
Chicago Fuse Mfg. Co.

For the addresses of the manufacturers listed here, please refer to their advertisements in this issue. The index to advertisers may be found on page 82.

General Electric Co.
Hubbell, Inc., Harvey
National Metal Molding Co.
Trumbull Electric Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Meter and Service
General Electric Co.
Trumbull Electric Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Sectional, Switch & Outlet
Appleton Electric Co.
Chicago Fuse Mfg. Co.

Brackets, Instrument
Mutual Electric & Machine Co.
Trumbull Electric Mfg. Co.

Brakes
Crane
Electric Controller & Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Disc
Electric Controller & Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Electric
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Brushes
Commutator
Calebaugh Self Lubricating Carbon Co.
Corliss Carbon Co.
General Electric Co.
Jeandron, W. J.
Morganite Brush Co., Inc.
Snarr & Co., Geo. W.
Westinghouse Elec. & Mfg Co.
Dynamic and Carbon
Corliss Carbon Co.
Jeandron, W. J.
Morganite Brush Co., Inc
Westinghouse Elec. & Mfg. Co.
Controller
Corliss Carbon Co.

Brush Holders
Baylis Company
Flower, D. B.
Westinghouse Elec. & Mfg Co.

Bus Bar Supports
General Electric Co.
Trumbull Electric Mfg. Co
Westinghouse Elec. & Mfg. Co.

Bushings
Appleton Electric Co.
National Metal Molding Co.

Cable Clamps
Electric Service Supplies Co.

Cable Hangers
Electric Service Supplies Co.

Cable Racks, End Bells and Accessories
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Cable Terminal Lugs.
Mutual Elec & Mach. Co.

Casting, Steel
Falk Corp., The

(Continued on page 78)

Surety Motors

Performance Guarantee
Backed by
Surety Bond

BONDED

What Shape Is It In Now ?

True Stories:

One of our Licensees recently purchased from a customer a 100-H.P., 450 R.P.M. motor. This motor came into the plant with a heavy steel gear on. To all outward appearances the motor was in perfect condition and would make an excellent buy for the purchaser. After removing the gear, which, by the way, took the time of three men two days, owing to the fact that the gear had been put on by hydraulic pressure and the key pounded in with a sledge hammer and had expanded, it was found that the shaft of the motor was sprung, which necessitated putting in a new shaft before the motor could be sold under the specifications of the Surety Motor Bonding Company.

There are cases where second hand dealers sell motors with the shafts sprung. The purchaser probably pays 25% cash with order and the balance sight draft against Bill of Lading, and then he has a machine that he has to add a lot of expense to to put it in operative condition or it is valueless to him.

This hazard is eliminated in buying a S.M.B. motor. If, by accident, some fault does get by, it will be remedied by the selling licensee. The Surety Bond guarantees that.

Ask the Licensees Named Below for Lists of and Full Information on Surety Bonded Renewed Motors:

Duquesne Electric & Mfg. Co., Duquesne Corner, Broad St. and Hamilton Ave., Pittsburgh, Pa.
Elliott Electric Co. . . . . 813 Superior Ave., W., Cleveland, Ohio
Miller-Seldon Electric Co. . . . . 1930 McGraw Ave., Detroit, Mich.
Willey-Wray Electric Co. . . . 1523-25-27 Central Parkway, Cincinnati, Ohio

Surety Motor Bonding Company

SURETY RENEWED MOTORS BONDED

SURETY MOTORS (BONDED)

133 W. Washington St., Chicago, Ill.

"What & Where to Buy"

(Continued from page 76)

Cement
Commutator
Martindale Electric Co.
Leather Belt
Chicago Belting Co.

Chains
American High Speed Chain Co.
Link-Belt Co.
Ramsey Chain Co., Inc.

Chucks, Drill & Tap
Skayef Ball Bearing Co.

Circuit Breakers
Automatic Reclosing Circuit Breaker Co.
Condit Electrical Mfg. Co.
Cutler-Hammer Mfg. Co.
Cutter Co.
General Electric Co.
Roller-Smith Co.
Westinghouse Elec. & Mfg. Co.

Clamps
Electric Service Supplies Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Clean Air Equipment
Milwest Air Filters, Inc.

Cleats
National Metal Molding Co.
Square D Co.
Trumbull Elec. Mfg. Co.
Thomas & Sons Co., R.

Clutches
Friction
Allis-Chalmers Mfg. Co.
Dodge Mfg. Corp.
Link-Belt Co.
Magnetic
Cutler-Hammer Mfg. Co.

Coal and Ash Handling Equipment
Link-Belt Co.

Coatings, Preservative
Sterling Varnish Co.

Coil Winding Machines
Armature Coil Equipment Co.
Electric Service Supplies Co.
Mutual Foundry & Machine Co.

Coil Winding Tools
Armature Coil Equipment Co.
Electric Service Supplies Co.
Mutual Foundry & Machine Co.

Coils, Choke
American Transformer Co.
Electric Service Supplies Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Coils, Induction
American Transformer Co.

Commutators
Cleveland Armature Wks.

Compensators
Automatic
Cutler-Hammer Mfg. Co
General Electric Co.
Industrial Controller Co.
Westinghouse Elec. & Mfg. Co.
Manual
Allis-Chalmers Mfg. Co.
Cutler-Hammer Mfg. Co.
General Electric Co.
Industrial Controller Co.
Westinghouse Elec. & Mfg. Co.

Conductors, Armored
Tubular Woven Fabric Co.

Conduit Benders
American Pipe Bending Mach. Co.

Conduits
American Circular Loom Co.
National Metal Molding Co.
Tubular Woven Fabric Co.

Connectors & Terminals
General Electric Co.
Mutual Electric & Machine Co.
Trumbull Electric Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Contacts, Carbon and Metal Graphite
Corliss Carbon Co.

Contact Rail Material
Electric Service Supplies Co.

Controller Fingers
Russell Mfg. Co.

Controllers
Automatic
Allen-Bradley Co.
Electric Controller & Mfg. Co.
Industrial Controller Co.
Lewellen Mfg. Co.
Monitor Controller Co.
Union Elec. Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Coal and Ore Bridges
Electric Controller & Mfg. Co.
Crane
Allen-Bradley Co.
Electric Controller & Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Drum Type
General Electric Co.
Union Elec. Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Machine Tool
Electric Controller & Mfg. Co.
Monitor Controller Co.
Union Elec. Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Manual
Allen-Bradley Co.
Electric Controller & Mfg. Co.
Industrial Controller Co.
Union Elec. Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Motor
Allen-Bradley Co.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Lewellen Mfg. Co.
Monitor Controller Co.
Union Elec. Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Conveyors
Link-Belt Co.
Weller Mfg. Co.

Cooling Air Filters
Midwest Air Filters, Inc.

Cord, Flexible
Hubbell, Inc., Harvey
Rome Wire Co.
Tubular Woven Fabric Co.
U. S. Rubber Co.

Couplings, Flexible
Allis-Chalmers Mfg. Co.
Bartlett Hayward Co.
Bond Co., Chas.
Dodge Mfg. Corp.
Electric Controller & Mfg. Co.
Falk Corp., The
Foote Bros., Gear and Machine Co.
Smith & Serrell

Crane Controllers
Drum Type
Cutler-Hammer Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Magnetic
Allen-Bradley Co.
Cutler-Hammer Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Graphite Compression
Allen-Bradley Co.

Crane Motors
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Cranes, Portable
Canton Foundry & Mach. Co.

Cross Arms
Electric Service Supplies Co.

Cutouts
Chicago Fuse Co.
General Electric Co.
Hubbell, Inc., Harvey
Mutual Electric & Machine Co.
Square D Co.
Thomas & Sons Co., R.
Trumbull Elec. & Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Cutters
Hole
Koch & Co., Paul W.

Cutters, Slotting
Commutator
Hullhorst Micro Tool Co.
Copper
Hullhorst Micro Tool Co.

Diagrams
Chittenden, Charles L
McGraw-Hill Book Co., Inc.

Disc Brakes
Electric Controller & Mfg. Co.

Dressing, Belt & Rope
Chicago Belting Co.

Drives
Smidth & Co., F. L.

Drives, Silent Chain
American High Speed Chain Co.
Link-Belt Co.
Ramsey Chain Co., Inc.

Dust Filters
Midwest Air Filters, Inc.

Dynamos
Allis-Chalmers Mfg. Co.
Marble-Card Elec. Co.
Westinghouse Elec. & Mfg. Co.

Electric Lighting
Westinghouse Elec. & Mfg. Co.

Elevators & Conveyors
Link-Belt Co.
Weller Mfg. Co.

Enamels, Wire, Wood and Steel
Sterling Varnish Co.

Engineers, Illuminating
Westinghouse Elec. & Mfg. Co.

Engines Oil
Allis-Chalmers Mfg. Co.
Falk Corp., The.

Factory Furniture
Westinghouse Elec. & Mfg. Co.

Factory and Mill Lighting
Westinghouse Elec. & Mfg. Co.

Fan Belts, Leather
Chicago Belting Co.

Fan Motors
Century Electric Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Fans
Exhaust and Ventilating
Century Electric Co.
Diehl Mfg. Co.
General Electric Co.
National Screw & Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Files, Commutator Slotting
Martindale Electric Co.

Filters, Air
Midwest Air Filters, Inc.

Fittings
Conduit
Appleton Electric Co.
Chicago Fuse Mfg. Co.
National Metal Molding Co.
Pipe
Westinghouse Elec. & Mfg. Co.

Fixtures, Lighting
American Fixture Co.
McGill Mfg. Co.
Sampson Axcess System, Inc.
Westinghouse Elec. & Mfg. Co.

For the addresses of the manufacturers listed here, please refer to their advertisements in this issue. The index to advertisers may be found on page 82.

Furnaces, Electric.
Westinghouse Elec. & Mfg. Co.

Fuse Clips
Trumbull Electric Mfg. Co.

Fuse Plugs
Hubbell, Inc., Harvey
Westinghouse Elec. & Mfg. Co.

Fuses
Chicago Fuse Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Renewable
Bussman Mfg. Co.
Chicago Fuse Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Gears
Chicago Rawhide Mfg. Co.
Diamond State Fibre Co.
Dodge Mfg. Corp.
Falk Corp., The
Foote Bros. Gear and Machine Co.
General Electric Co.
Link-Belt Co.
Smith, Winfield H.
Westinghouse Elec. & Mfg. Co.

Generating Sets
Allis-Chalmers Mfg. Co.
General Electric Co.
Marble-Card Electric Co.
Triumph Electric Co.
Westinghouse Elec. & Mfg. Co.

Generators
Allis Co., The Louis
Allis-Chalmers Mfg. Co.
Burke Electric Co.
Electro Dynamic Co.
General Electric Co.
Hertner Electric Co.
Marble-Card Electric Co.
Reliance Elec. & Eng. Co.
Triumph Electric Co.
Westinghouse Elec. & Mfg. Co.

Glue Pots
Westinghouse Elec. & Mfg. Co.

Grinders
Martindale Electric Co.

Grinding Machinery
Smidth & Co., F. L.

Hammers, Rawhide
Chicago Rawhide Mfg. Co.

Hangers, Line Shaft
Dodge Mfg. Corp.
Link-Belt Co.

Hangers, Safety Disconnecting
Cincinnati Specialty Co.
Thompson Electric Co.

Heating & Ventilating Equipment
Midwest Air Filters, Inc.

Heating Devices, Industrial
Campbell Mfg. Co.
Despatch Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Hoists
General Electric Co.
Link-Belt Co.

Instrument Transformers
American Transformer Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Instruments, Electrical
Graphic
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Indicating
Biddle, James G.
General Electric Co.
Taylor Instrument Co.
Westinghouse Elec. & Mfg. Co.
Weston Electrical Ins't Co.
Integrating
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Scientific and Testing Service
Biddle, James G.
Cory & Son, Inc., Chas.
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Weston Electrical Ins't Co.

Insulating Material
Compounds, Paints and Varnishes
Dolph Co., John C.
General Electric Co.
Irvington Varnish and Insulator Co.
Martindale Electric Co.
Sterling Varnish Co.
Westinghouse El. & Mf. Co.
Comp. Cloth and Paper
Carlson-Dunn Co.
General Electric Co.
Sterling Varnish Co.
Westinghouse Elec. & Mfg. Co.
Fibre
Diamond State Fibre Co.
General Electric Co.
Irvington Varnish and Insulator Co.
Mitchell-Rand Mfg. Co.
Molded
Cutler-Hammer Mfg. Co.
Mitchell-Rand Mfg. Co.
Tape and Webbing
Anchor Webbing Co.
Carlson-Dunn Co.
General Electric Co.
Irvington Varnish and Insulator Co.
Okonite Co., The
U. S. Rubber Co.
Westinghouse Elec. & Mfg. Co.

Insulators
Electric Service Supplies Co.
General Electric Co.
Irvington Varnish and Insulator Co.
Square D Co.
Thomas & Sons Co., R.
Westinghouse Elec. & Mfg. Co.

Ladles, Pouring
Dunn, J. Struthers.

Lamp Guards
Electric Service Supplies Co.
Flexible Steel Lacing Co.
Hubbell, Inc., Harvey
McGill Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Lamps
Arc
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Incandescent
General Electric Co.
Nitrogen
Westinghouse Elec. & Mfg. Co.
Trouble
McGill Mfg. Co.

Lightning Arresters
Chicago Fuse Mfg. Co.
Electric Service Supplies Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Lighting, Industrial
American Fixture Co.
General Electric Co.
National Screw & Mfg. Co.
Sampson Axcess System, Inc.
Westinghouse Elec. & Mfg. Co.

Line Material
Electric Service Supplies Co.
General Electric Co.
Thomas & Sons Co., R.
Westinghouse Elec. & Mfg. Co.

Magnets
Cutler-Hammer Mfg. Co.
Dudlo Mfg. Co.
Electric Controller & Mfg. Co.

Malleable Castings
Pittsburgh Malleable Iron Co.

Material Handling Equipment
Link-Belt Co.
Weller Mfg. Co.

Meters
Cory & Son, Inc., Chas.
General Electric Co.
Roller-Smith Co.
Westinghouse Elec. & Mfg. Co.

Meter Testers
General Electric Co.
Westinghouse Elec. & Mfg. Co.

(Continued on page 80)

"What & Where to Buy"

(Continued from page 78)

Mica, Undercutting Machines
Hullhorst Micro Tool Co.
Molding, Metal
Appleton Electric Co.
National Metal Molding Co.
Motors
Allis, The Louis Co.
Allis-Chalmers Mfg. Co.
Baldor Electric Co.
Burke Electric Co.
Century Electric Co.
Champion Electric Co.
Diehl Mfg. Co.
Electric Blower Co.
Electric Controller & Mfg. Co.
Electro Dynamic Co.
General Electric Co.
Hertner Electric Co.
Jeannin Electric Co.
Marble-Card Electric Co.
Master Electric Co.
National Screw & Mfg. Co.
Phoenix Electric Co.
Reliance Electric & Eng. Co.
Roth Bros. & Co.
Sturtevant Co., B. F.
Triumph Electric Co.
Wesche Elec. Co., B. A
Westinghouse Elec. & Mfg. Co.
Motor Generators
Allis Co., The Louis
Allis-Chalmers Mfg. Co.
Burke Electric Co.
Hertner Electric Co.
Marble-Card Electric Co.
Reliance Elec. & Engr. Co.
Triumph Electric Co.
Westinghouse Elec. & Mfg. Co.
Ovens, Electric
Despatch Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Packings, Hydraulic
Chicago Belting Co.
Paints, Wood and Steel
Sterling Varnish Co.
Panel Boards
General Electric Co.
Mutual Electric & Machine Co.
Westinghouse Elec. & Mfg. Co.
Panels, Switchboard
General Electric Co.
Mutual Electric & Machine Co.
Westinghouse Elec. & Mfg. Co.
Pinions
Foote Bros., Gear and Machine Co.
Pipe Benders
American Pipe Bending Mach. Co.
Appleton Electric Co.
Pipe Cutters
Crown Die & Tool Co.
Plugs
General Electric Co.
Hart Mfg. Co.
Hubbell, Inc., Harvey
National Metal Molding Co.
Trumbull Electric Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Potentiometers
Biddle, James G.
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Power Transmission Appliances
Allis-Chalmers Mfg. Co.
Bartlett Hayward Co.
Bond Co., Chas.
Dodge Mfg. Corp.
Lewellen Mfg. Co.
Link-Belt Co.
Smidth & Co., F. L.
Weller Mfg. Co.
Projectors, Floodlighting
Electric Service Supplies Co.
Westinghouse Elec. & Mfg. Co.
Protective Devices
Condit Elec. Mfg. Co.
General Elec. Co.
Industrial Controller Co.
Westinghouse Electric and Mfg. Co.
Pull Sockets
Hubbell, Inc., Harvey
Pulleys
Canton Foundry & Mach. Co.
Dodge Mfg. Co.
Link-Belt Co.
Smith, Winfield H.
Pulling Tools
Premier Electric Co.
Pulverizing Machinery
Smidth & Co., F. L.
Pumps
Centrifugal
Allis-Chalmers Mfg. Co.
Reciprocating
Allis-Chalmers Mfg. Co.
Racks, Machine
Foote Bros. Gear and Mach Co.
Receptacles
Hart Mfg. Co.
Rectifiers
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Reels, Extension
Appleton Electric Co.
Cincinnati Specialty Co.
Reflectors
Hubbell, Inc., Harvey
Thompson Electric Co.
Westinghouse Elec. & Mfg. Co.
Regulators
Induction Voltage
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Speed
Cutler-Hammer Mfg. Co.
Industrial Controller Co.
Relays, Overload
Allen-Bradley Co.
Dunn, J. Struthers
Hart Mfg. Co.
Repair Data
McGraw-Hill Book Co., Inc.
Resistance Units
General Electric Co.
Monitor Controller Co.
Westinghouse Elec. & Mfg. Co.
Rheostats
Allen-Bradley Co.
Cutler-Hammer Mfg. Co.
General Electric Co.
Industrial Controller Co.
Union Electric Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Rivets
Hubbell, Inc., Harvey.
Roller Chains
Link-Belt Co.
Rosettes
Hubbell, Inc., Harvey
National Metal Molding Co.
Sanders
Nichols-Lintern Co., The
Schools
Ft. Wayne Correspondence School
Screws, Machine
Hubbell, Inc., Harvey
Searchlights
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Second-Hand Apparatus
Advance Electric Co.
Fuerst-Friedman Co.
Gregory Electric Co.
Miller-Seldon Electric Co.
Surety Motor Bonding Co.
Shells, Expansion
Paine Co.
Signals, Indicating
Nichols-Lintern Co., The
Silent Chain Drive
Link-Belt Co.
Slot Cleaning Tools, Commutator
Martindale Electric Co.
Slotters, Commutator
Green Equipment Corp.
Hullhorst Micro Tool Co.
Martindale Electric Co.
Sockets and Receptacles
General Electric Co.
Hubbell, Inc., Harvey
National Metal Molding Co.
Westinghouse Elec. & Mfg. Co.
Solder
Allen Co., L. B.
Burnley Battery & Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Soldering Compounds
Allen Co., L. B.
Burnley Battery & Mfg. Co.
McGill Mfg. Co.
Ruby Chemical Co.
Soldering Irons
Electrahot Appliances, Inc.
Space Heaters
Cutler-Hammer Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Wiegand, Edwin L.
Speed Reducers
Falk Corp., The
Foote Bros. Gear & Mach. Co.
Starters, Motor
Allen-Bradley Co.
Allis-Chalmers Mfg. Co.
Cutler-Hammer Mfg. Co.
General Electric Co.
Square D Co.
Union Elec. & Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Stones, Commutator
Green Equipment Corp.
Martindale Elec. Co.
Stop Signals
Nichols-Lintern Co., The
Stops, Electric Limit
Electric Controller & Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Straps, Leather
Chicago Belting Co.
Stringers, Steel
Midwest Steel & Supply Co., Inc.
Strip Heaters
Westinghouse Elec. & Mfg. Co.
Wiegand, Edwin L.
Substations, Outdoor
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Supplies, Electrical
Commonwealth Edison Co.
Flower, D. B.
Green Equipment Corp.
General Electric Co.
Hubbell, Inc., Harvey
Nagel Elec. Co., W. G.
Trumbull Elec. Mfg. Co.
Weeks, Arthur B.
Westinghouse Elec. & Mfg. Co.
Supplies, Railway
Electric Service Supplies Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Switchboard Supplies
General Electric Co.
Trumbull Elec. Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Switchboards
Allen-Bradley Co.
Allis-Chalmers Mfg. Co.
Condit Electric Mfg. Co.
General Electric Co.
Mutual Electric & Machine Co.
Trumbull Elec. Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Battery Charging
Allen-Bradley Co.
Crane
Electric Controller & Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Switches
Air Brake and Pole Top
Condit Electric Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Automatic
Allen-Bradley Co.
Electric Controller & Mfg. Co.
Industrial Controller Co.
Monitor Controller Co.
Union Elec. & Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Battery
Hart Mfg. Co.
Conduit Box
McGill Mfg. Co.
Disconnecting
Electric Service Supplies Co.
General Electric Co.
Industrial Controller Co.
Mutual Electric & Machine Co.
Trumbull Electric Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Float
General Electric Co.
Industrial Controller Co.
Westinghouse Elec. & Mfg. Co.

For the addresses of the manufacturers listed here, please refer to their advertisements in this issue. The index to advertisers may be found on page 82.

Fuse
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Knife
Condit Electric Mfg. Co.
Cutler-Hammer Mfg. Co.
Cutter Co.
General Electric Co.
Mutual Electric & Machine Co.
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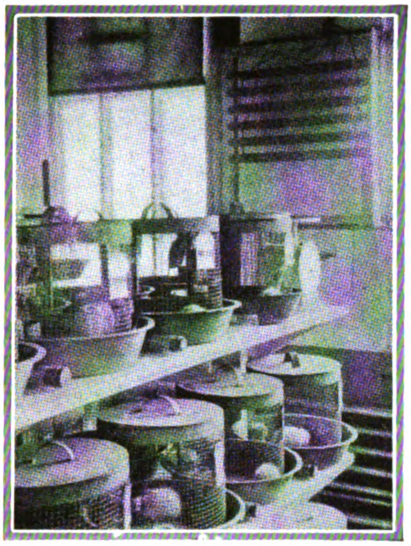
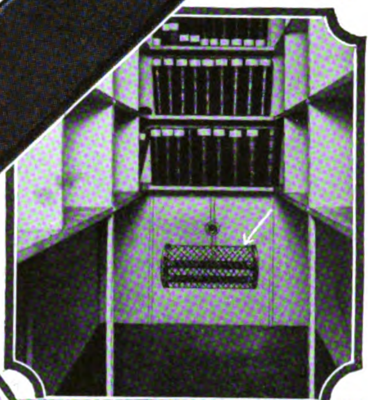


Electrically Heated Apartment for Rats

In the new Wistar Institute Colony Bldg., which houses thousands of albino rats, the temperature of the colony rooms is kept within the range of 65° to 75° F. Six C-H Electric Space Heaters are placed at each end of the room to supplement the heating system. They can be switched on quickly when the temperature drops at any time of the day or night.

(From "Patchwork," published by E. L. Patch Co., Boston.)

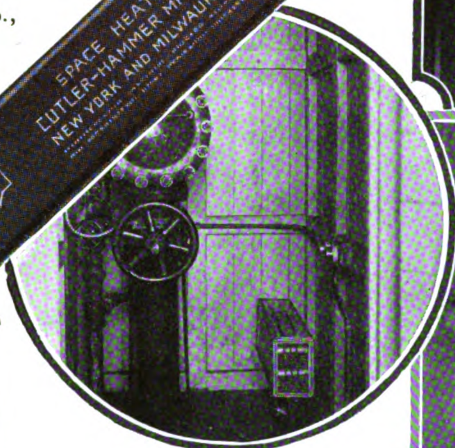
C-H Space Heaters in vault keep it warm and dry.



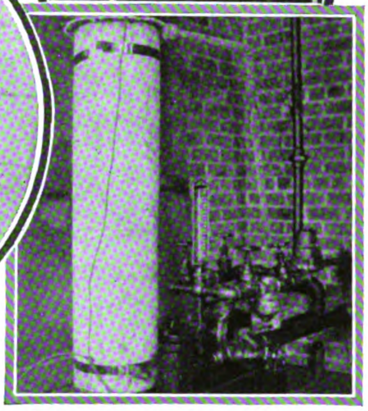
All Cutler-Hammer Electric Space Heaters are stamped with the "C-H" Trademark.

C-H

SPACE HEATER
CUTLER-HAMMER MFG. CO.
NEW YORK AND MILWAUKEE



Two C-H Space Heaters in Sprinkler System Valve House.



Group of three Space Heaters mounted on spider surrounding fuel oil pipe to keep it fluid.

Here Are Some of the 121 Proven Uses

Sprinkler Systems	Incubators
Valve Houses	Brooders
Gum Drying Ovens	Around Fuel Oil Pipes
Negative Drying Cabinets	In Watchman Towers
Room Heating	Cafeteria Serving Tables
Mine First Aid Stations	Vaults
Theatre Ticket Booths	Garages
In connection with Ventilating Systems	Warming Ovens
Crane Cabs	Foot Warmers
Coal Tipples	Substations
	Pits
	Manholes

For 100 Heating Uses

Flat and two feet long this original Cutler-Hammer Space Heater is adapted for scores of uses, some of which are mentioned in the panel to the left.

Clean, Safe, Easily Installed
500 Watts (like an Electric Iron)

The insulated mounting eyelets make installation easy. Connection may be made to either direct or alternating current light or power circuits.

If your electric supply jobber cannot supply you promptly, get in touch with the Cutler-Hammer branch office nearest you.

Send for this booklet

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